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1491 Issued May 7, 1913.

HAWAII AGRICULTURAL EXPERIMENT STATION,

E. V. WILCOX, Special Agent in Charge.

ANNUAL REPORT

OF THE

HAWAII AGRICULTURAL EXPERIMENT STATION

FOR

1912.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

E. V. Wilcox, *Special Agent in Charge.*
J. Edgar Higgins, *Horticulturist.*
W. P. Kelley, *Chemist.*
C. K. McClelland, *Agronomist.*
D. T. Fullaway, *Entomologist.*
W. T. McGeorge, *Assistant Chemist.*
Alice R. Thompson, *Assistant Chemist.*
C. J. Hunn, *Assistant Horticulturist.*
V. S. Holt, *Assistant in Horticulture.*
C. A. Sahr, *Assistant in Agronomy.*
F. A. Clowes, *Superintendent Hawaii Substations.*
W. A. Anderson, *Superintendent Rubber Substation.*
J. de C. Jerves, *Superintendent Homestead Substation.*
J. K. Clark, *Superintendent Waipio Substation.*

LETTER OF TRANSMITTAL.

Hawaii Agricultural Experiment Station,
Honolulu, Hawaii, July 15, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Hawaii Agricultural Experiment Station for the fiscal year ended June 30, 1912.

Respectfully,

E. V. Wilcox,
Special Agent in Charge.

Dr. A. C. True,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
James Wilson,
Secretary of Agriculture.

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ANNUAL REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION FOR 1912.

SUMMARY OF INVESTIGATIONS.

By E. V. Wilcox, *Special Agent in Charge.*

BUILDINGS AND GROUNDS.

As the work of the different members of the station staff continues, new conveniences are required in the station buildings for special purposes. Many interior changes have been made to better meet the new requirements. In addition to interior alterations most of the buildings have been repainted and otherwise repaired in order to protect them more fully against injurious effects of the weather, which are particularly noticeable under tropical conditions. A glass house has been erected for propagating purposes, and the old one, which had become quite unsuited to our purposes, was torn down and partly used in the construction of the new glass house. This structure is made proof against ants by means of cement pillars standing in water. Arrangements for bottom heat in the main propagating bed have been made by means of circulating water which is heated by sunlight in an outside tank. An additional workhouse has been erected for the use of the horticultural department. This contains rooms for seeds, fruit, storage of spraying machinery, and for general inside work purposes.

The trial grounds, which have been used for rice experiments and certain other field tests for several years, could no longer be leased by the station, and in order to continue experiments with rice and with certain other crops, such as cotton, taro, and soy beans, another similar area of about 2 acres near Nuuanu Avenue will be leased for use during the next few years or as long as such experiments seem necessary. With the extension of the cultivated areas on the various substations it has been found possible to carry on such field experiments as were necessary under better conditions than could be obtained on the irregular and sloping soils of the experiment station grounds. Comparatively small areas, therefore, on the main station grounds have been put under cultivation in addition to those which had been so used in previous years. A few acres of shallow soil underlain with partly cemented cinder-rock were planted to pigeon peas and jack beans for the purpose of increasing the supply of seed of these crops to be distributed. The yield was fairly good, although the year has been excessively dry and no irrigation was possible on this particular area. On the 2 acres of ground on Magazine Hill belonging to the experiment station no attempt has been made to introduce a water supply by pipes or otherwise, since it has been decided to use this land only in testing drought-resistant qualities of certain grasses, forage plants, and cottons. The test during the present year has been unusually severe on account of the great length of the season of drought.

CHANGES IN THE STAFF.

During a portion of the year Mr. W. P. Kelley and Miss Alice R. Thompson were absent on furlough, carrying on special studies at the University of California and Columbia University, respectively. Mr. F. A. Clowes was appointed in charge of the Hawaii substations, Mr. W. A. Anderson, in charge of the rubber substation at Nahiku, Maui, Mr. J. de C. Jerves, in charge of the Homestead substation on Kauai, and J. K. Clark, in charge of the Waipio substation on Oahu.

DEMONSTRATION FARMS.

The work inaugurated on the demonstration farms has met with satisfactory success. At the small substation in Hilo attention has been devoted chiefly to the study of varieties of taro, the various methods of propagating these plants, the effect upon yield from planting at different distances apart, and the results obtained from the use of different combinations of fertilizers. Gradually, also, a collection is being made of the known taro varieties for the purpose of determining which names are synonyms and which varieties can really be distinguished by persistent horticultural characteristics. The results of the taro work at Hilo will be ready for publication in the near future. In addition to the taro experiments at Hilo, attention has been given to banana cultivation, particularly in determining the proper planting distance to be used in that climate and in determining the differences between what seem to be two strains of the Bluefields variety.

At Glenwood, where the station has control of 15 acres of land, a more pretentious equipment has been secured and a much greater variety of experiments is being carried on. The neighborhood of Glenwood seems to be best adapted to dairying, and for this reason a dairy equipment has been secured for the purpose of determining the various conditions which will conduce to the largest profit from butter making in that locality. A great variety of forage plants is being tested out, and the equipment of modern butter-making machinery will enable the substation to produce butter for sale on the Honolulu market. One of the objects of the dairy work at this substation is to bring the various dairymen together for the purpose of ultimately establishing a cooperative dairy association among them which can take over the practical work along this line and secure to its members greater profits from butter making than are now secured.

The soils of the Glenwood station are of peculiar character and require special study to overcome the unfavorable effects of excessive rain and lack of an efficient temperature for plant growth. In order to determine to what extent the unsatisfactory growth of various plants in that neighborhood is due to local climatic conditions, a number of pot experiments have been planned to be carried out on the station grounds in Honolulu with soils taken from the Glenwood substation.

At the rubber substation in the Nahiku district of Maui attention has been devoted chiefly to the use of intercrops between rubber, planting Ceara cuttings from the most heavily yielding trees, the cultivation of awa, the tapping of Ceara, and the extraction of kukuinut oil. It has been found that awa does not thrive well when planted in cultivated soil without the benefit of shade. Further experiments will be carried on under partial shade of rubber trees or in the neighboring forest. Broom corn planted between young Ceara rubber trees produced a good yield of satisfactory brush. One acre has been planted with 200 cuttings from Ceara trees which had shown themselves to be exceptionally heavy producers of latex. It is hoped that from these a uniform set of trees will be obtained which will all be high yielders. Nearly all possible methods of tapping Ceara have been tested, with the result that the cost of collecting rubber has been greatly reduced below the figures obtained in previous experiments reported by this station. Moreover, the machinery now used in preparing rubber yields a better product with a lower percentage of resin, protein, and ash. It appears that these impurities are reduced in percentage in proportion as the pressure is increased between the rollers of the mangling machine.

On the Homestead substation about 2 acres are devoted to varieties of peaches. This fruit thrives especially well on Kauai and is a favorite tree in the dooryards of the homesteaders. A number of highly recommended varieties of peaches were obtained from Florida for testing at the substation. At present they are doing well. Cultural and fertilizer studies are also being carried on with pineapples, there being 1 acre devoted to this crop at the substation. In addition to peaches and pineapples attention is being given to onions, Irish potatoes, sweet potatoes, corn, and a considerable variety of other garden vegetables. The work of this substation has been almost altogether of a practical nature. It has attracted the attention of the homesteaders on the island, and the superintendent has been able to spread much useful information regarding cultural methods, varieties, spraying for fungus diseases and insects, and miscellaneous information of a practical nature.

At the Waipio substation on Oahu the tests thus far have been for the most part along the line of dry farming. During the past season the drought was so unusually prolonged that most of the crops were put to a severe test. Onions were unable to mature bulbs of marketable size, jack beans grew fairly well even when planted during the progress of the drought, and Irish potatoes, sweet potatoes, sorghum, and broom corn were badly affected by dry weather. Of all the legumes tested at Waipio, the velvet bean endured the drought best. Where no windbreak protection was offered to cotton at Waipio it did not mature a satisfactory crop, partly on account of the cool nights and partly on account of the excessive evaporation of the moisture in the soil during the constant trade winds.

ENTOMOLOGICAL INVESTIGATIONS.

The chief efforts of the entomologist during the year were devoted to a study of the Mediterranean fruit fly, mosquitoes, certain parasites of the cotton bollworm, algaroba bean weevils, and scale insects. The practical work in combating the Mediterranean fruit fly has been carried on under the auspices of the Territorial government. The entomologist and the special agent in charge of this station, however, have been consulted and have taken part in all of the active measures which have been adopted. According to the present plan of the campaign the parasites of the Mediterranean fruit fly and cotton bollworm which it is hoped to obtain in Africa will be handled, bred, and distributed by the entomologist of this station. In addition to the usual breeding experiments to determine the variety of fruits affected by the Mediterranean fruit fly, considerable attention has been given to trapping and to the use of a poisoned spray in combating the fruit fly. A number of trips were also made to the Kona coffee district to ascertain the extent of infestation of coffee with fruit fly, the amount of damage actually done by the fly, and to initiate practical measures for controlling the prevalence of the pests in the coffee orchards.

Some attention was given to the study of the life histories and habits of the three species of mosquitoes which are known to occur in the Territory. The immediate occasion for taking up this work was the fear of a possible outbreak of yellow fever on account of the occurrence of the yellow fever mosquito. It was soon found that the yellow fever mosquito was much less common than (*Stegomyia*) *Aëdes scutellaris*, although the latter species was apparently introduced into Hawaii later than the yellow fever mosquito. Much useful information was collected regarding the habits of all three species of mosquitoes, particularly with reference to the situations under which the larvæ breed.

HORTICULTURAL INVESTIGATIONS.

The energies of the horticultural department have been devoted largely to the study of pineapples and methods of propagating the avocado, mango, papaya, and hibiscus. The importance of the pineapple industry of Hawaii is growing greater day by day. The output of canned pineapples, which it was feared two years ago had almost reached the limit of the market for this product, has been greatly increased, and arrangements are now being made to nearly double the area devoted to pineapples. The demand for canned pineapples has taken all of the product which could be supplied and seems to warrant this great extension of the industry. Pineapples are second only to sugar cane in commercial importance in Hawaii. The quality of the product has remained uniform, owing to the fact that there are only two commercial varieties of pineapples in Hawaii and that these varieties are of quite similar nature. Recent observations, however, indicate that these varieties have become mixed on nearly all of the plantations and that one of them is decidedly inferior to the other. The inferior variety apparently came from Queensland, while the superior one is apparently the true Smooth Cayenne. The growers are gradually eliminating the less desirable variety. A press bulletin[1] covering the various cultural and marketing features of pineapples was published during the year. Continuation of experiments in methods of propagating the avocado and mango has developed the fact that these fruits may be inarched or budded almost with as much facility as is known to be the case with fruits of temperate climates. The difficulties which had hitherto made the propagation of superior varieties of avocados and mangoes uncertain are rapidly disappearing.

Similarly with papayas there is a good prospect now that strains of seed will soon be obtained which will show almost a complete uniformity in product. Hitherto this has been far from the actual state of affairs. Much seed obtained by the method of crossing male and female flowers showed a variation which was difficult to control and the products of which could not in any case be predicted.

On account of the restrictions placed on bananas by the recent California quarantine law, it has been found necessary to take up in a systematic manner the methods of packing, which promise to make possible the shipment of bananas to California without danger from scale insects and without injury to the bananas. At present it is hoped that the cooperation of the steamship companies can be obtained in furnishing facilities for shipping bananas without any packing around the bunches. It will then be possible to inspect the bunches more effectively and conveniently and to avoid the heating and other injurious effects of the various kinds of packing which have hitherto been used.

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[1] Hawaii Sta. Press Bul. 36.

During the coming year it is hoped to bring some of the work which has been in progress with hibiscus to a conclusion and to publish the results in bulletin form.

CHEMICAL INVESTIGATIONS.

One of the chief lines of work carried on by the chemical department has been a study of the function and distribution of manganese. Some of these results were published during the year in bulletin form.[1] The work of the station on manganese soils is being closely followed by pineapple growers. It appears impossible by any method thus far adopted to grow pineapples successfully on soils which contain more than 2 per cent of manganese. On highly manganiferous soils not only do the leaves turn decidedly yellow or even whitish but the fruits are pink rather than of the normal color and are too acid or otherwise disagreeable in flavor. In selecting new areas for the extension of the pineapple industry the prospective growers have had manganese determinations made in order to avoid the areas in which a high percentage of manganese is found.

Evidence is accumulating from time to time of the importance of a reasonable balance between lime and magnesia in the soils of Hawaii. In some soils the ratio is greatly disturbed by the excessive prevalence of magnesia and in others by an excess of lime. Satisfactory results can not be obtained on either type of soil with the majority of crops. Since the chief injurious effect of manganese seems to be in causing plants to absorb too much lime and too little magnesia, a systematic set of experiments has been planned to determine whether the effects of manganese can not be overcome by adding magnesia to such soils. This question will be thoroughly investigated in a series of pot experiments and on a commercial scale in the pineapple fields.

In decorticating sisal a large amount of waste pulp is obtained of which no economic use has been made in Hawaii. A request was made upon the station to investigate the possible utilization of this pulp. The chemical work was done by the assistant chemist and resulted in determining that the greatest practical value of this pulp was for fertilizing purposes. Sisal removes large quantities of mineral plant food from the soil which can all be returned by the use of the pulp as a fertilizer. The pulp will also add a quantity of humus to the soil. One of the striking scientific results of this investigation was the determination of lactic acid as the normal vegetable acid of sisal. The percentage of acid increases from the base to the tip of the leaf. It is not likely that the acid can be extracted from the pulp with profit. The trouble which the presence of the acid has caused in corroding machinery has largely been overcome by the use of gun metal in the place of iron.

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[1] Hawaii Sta. Bul. 26.

A special study has been made of sulphur and chlorin in the rice plant. Many difficulties have been met with in determining the sulphur, and particularly on account of the occurrence of sulphur in gas in the laboratory. This trouble was overcome by the use of alcohol lamps in the place of gas. When ammonium sulphate was used in pot cultures in sterilized silica sand it was found that the assimilation of ammonia and mineral sulphur took place in such proportions as to indicate clearly that the plant takes up ammonium sulphate as such.

In testing the effect of various fertilizer combinations on taro it was found that the best form in which nitrogen can be applied is ammonium sulphate or an organic form of nitrogen. The effect of nitrate of soda was in some cases equally marked in so far as the total yield was concerned, but it required a much greater weight of taro to produce the same amount of poi when nitrogen was applied as nitrate of soda.

A special examination of Hawaiian soils is being made for the purpose of determining the form in which nitrogen normally occurs in the soil. It appears from preliminary work that the amount of ammonia in certain soils may be 100 times that of nitrate. This problem is of great importance in the rational treatment of our soils, and its study will be continued during the coming year.

Chemical work on various rubbers has been prosecuted in cooperation with the rubber substation on Maui. In addition to work in determining the percentage of resin, ash, protein, and true rubber gum in Ceara and Hevea rubbers, a study has been begun of a new rubber product from *Euphorbia lorifolia.* This tree covers an area of about 6,000 acres in the Kona district of Hawaii, and yields a large quantity of latex, which can be coagulated only by use of heat or alcohol. The dry matter of the latex contains 14 to 17 per cent rubber and about 60 per cent of a resin which appears to be nearly, if not quite, identical with chicle gum.

In cooperation with the Philippine Bureau of Science the chemical department made observations during the year on the actinic power of the sun, with the interesting result that the actinic effect of the sun is highest at the spring and fall equinoxes and lowest at the summer and winter solstices.

AGRONOMICAL INVESTIGATIONS.

Cotton continues to occupy the interest of a considerable number of planters. It has been quite conclusively proved that this crop does not thrive well on the upper lands unless well protected against trade winds nor in any locality where the temperature is relatively low. On the other hand, excellent results in yield and quality have been uniformly obtained at sea level and in protected localities on the leeward side of the various islands. On account of the fact that Caravonica cotton is less susceptible to attack of the pink bollworm than Sea Island there is a tendency to grow Caravonica cotton chiefly. The prices obtained for this cotton have ranged from 18½ to 20 cents, and a report received from one mill states that the fiber is equal to the best rough Peruvian. In actual strength Caravonica lint appears to be superior to all other varieties of which breaking tests have been made. From a comparative test made by a mainland cotton mill it appears that the value of Caravonica lint obtained from the saw gin is so nearly equal to that from the roller gin that the economic considerations are in favor of the use of a saw gin.

Yields obtained from rices imported from Japan have continued to be satisfactory. Milled samples of this rice have been distributed among various inhabitants of the Territory who were interested in comparing their culinary qualities. There is a growing belief that these rices raised in Hawaii from Japanese seed are practically identical with rice directly imported from Japan. A systematic study is being made of the forage grasses of the Territory. In addition to the species which were native to Hawaii and those which were introduced long ago, many species have been brought in from various tropical and temperate climates to test their adaptability to our wet and dry ranges. The experiments have taken various forms. In some cases the seed was simply sown on the range without any previous preparation, being scattered upon the natural sod of the range. On at least one ranch elaborate planting operations have been carried on during which the ground was plowed and thoroughly prepared before seeding. These operations while relatively expensive promise to give economic returns in forage.

MISCELLANEOUS.

Dynamite has been commonly used for many years on the station grounds in preparing soil for planting trees. This has been found to be the cheapest method by which good soil conditions can be given for the extension of tree roots. During the year a special grade of dynamite was tested in plowing heavy soils for pineapples, in loosening the soil about the roots of growing trees, in improving the drainage in lawns, and in furnishing an outlet for water in small sink-like areas in which the surface water tended to collect. These tests have in all cases shown the large range of applicability of dynamite to farming operations and its effectiveness and economy.

Among the unusual feedstuffs which are used in Hawaii mention may be made of honohono, algaroba bean meal, soy bean cake, and tree fern trunks. In the extremely wet district of Glenwood, Hawaii, honohono has been found to be one of the best forage crops for dairy cows. It ratoons readily and rapidly without particularly diminishing the yield if stable manure be spread over the ground as fast as the crop is cut off.

While a special machine had been patented for the preparation of a meal from the algaroba bean, the use of the machine was not pushed in a commercial way and great quantities of the beans were being allowed to go to waste. One of the feed companies of Honolulu has at last made arrangements to secure another machine for grinding algaroba beans. This machine is essentially identical with one of the types of alfalfa meal mills. A very satisfactory product is produced, and arrangements have been made to lease land covered with algaroba and to purchase beans on a large scale. It is believed that this product will to some extent take the place of rolled barley, which is now imported in large quantities into the Territory.

The product remaining from the manufacture of soy sauce is a cake containing a high percentage of the usual nutrients in feeding stuffs. The only disadvantage connected with this feeding stuff is the great amount of salt which it contains. It has been found, however, that this can readily be removed by water, leaving a product which has proved valuable for feeding to pigs.

An analysis was made of the common tree fern trunk which occurs in large areas in the mountains. This trunk is widely used as a pig feed either raw or after being cooked. The greater portion of the trunk is of a starchy nature and is much relished, particularly after being boiled. Near the volcano of Kilauea some of these trunks are cooked by being placed over steam cracks.

Among the lines of investigation which have been undertaken and are still unfinished mention should be made of the disease of chickens caused by the prevalence of Manson's eye worm, the extraction of kukui-nut oil, a general soil survey, a study of artificial breeding methods with bees, and a horticultural investigation of hibiscus.

REPORT OF THE ENTOMOLOGIST.

By D. T. Fullaway.

The entomologist was absent in the island of Guam during the early part of the fiscal year, returning to Hawaii on November 3. The accompanying report covers the entomological work done from that date to the end of the fiscal year—a period of about eight months. The routine work of the office, however, was attended to throughout the year. Among other duties performed, numerous inquiries in regard to insect pests were answered personally or by letter. The insect collections of the station were adequately cared for, much material added, and the whole rearranged in new cabinets (following the arrangement in the Fauna Hawaiiensis).

Investigations undertaken in this period were largely in response to pressing demands of the moment, and little opportunity was enjoyed for systematic study of the more important field-crop pests. Some observations of a miscellaneous nature are subsequently noted.

A threatened epidemic of yellow fever, early in November, made desirable a study of the local mosquitoes, which was undertaken by the station. The investigation extended over several months and disclosed much new and useful information concerning the mosquitoes. In publishing the results of the investigation, the writer desires to acknowledge his obligation to the entomological staff of the Sugar Planters' Station, and especially to Mr. Swezey, for much of the material.

MOSQUITOES.

Three species of mosquitoes are found in the Hawaiian Islands—*Culex quinquefasciatus* (*C. fatigans*), the common night mosquito, and *Aëdes calopus* (*Stegomyia fasciata*) and (*Stegomyia*) *Aëdes scutellaris*, usually referred to as day mosquitoes—all three introduced with shipping within the memory of the Hawaiians. From the focal points of introduction the species have spread generally throughout the islands, and in the presence of the conditions requisite for their development are found everywhere from the coast far up into the mountains. The night mosquito differs greatly from the day mosquitoes not only in habits but in the appearance of the larvæ and the adults, while the two day mosquitoes are generally much alike, with certain small distinguishing characters.

NIGHT MOSQUITO.

The night mosquito is a typical culicine and has a wide distribution in the Tropics of both hemispheres. The localities given by Theobald[1] are: Ceylon, Burma, Straits Settlements, China, East Indies, Japan, West Indies, South and Central America, southern part of North America, Natal, Mombasa, Pemba Island (East Africa), Zanzibar, Egypt, Sudan, British Central Africa, Senegambia, Australia, Mauritius, Seychelles, Sarawak, Fiji, Siam, India, Cape Town, Delagoa Bay, Africa, Honolulu. The exact date of its introduction in these islands is now disputed. The historian Alexander states on the testimony of old residents that it was brought to the islands on the ship *Wellington* in 1826. On the other hand, Kamakau, one of the older Hawaiian historians, states that fleas and mosquitoes were unknown in the Hawaiian group until the arrival of Cook's ships (1778–79), implying that they were introduced then. From the evidence adduced, it would seem that the later date is probably correct. For many years this was the only species of mosquito found here, the day mosquitoes coming much later. The species, as already stated, is found in the mountains as well as along the shore (for the simple requirement of its existence, the presence of standing bodies of water, is a universally prevalent condition), and wherever it breeds in large numbers it is the scourge of all unprotected persons at night. The eggs (Pl. I, 1) of this species are laid in rafts several millimeters long, comprising several hundred eggs placed on end and standing together side by side. The eggs taper slightly toward the upper end, so that the upper surface of the mass is a trifle concave. The raft is laid on the surface of the water and is perfectly buoyant. After a day or two the eggs hatch and several hundred tiny "wrigglers" of less than a millimeter's length emerge from the lower end of the respective eggs. These wrigglers, or larvæ, are structurally fitted for an aquatic life. They assume an upright position in the water with head down, jaws busily sweeping food into the mouth, and the respiratory apparatus, which in this mosquito opens externally through a siphon projecting from the penultimate segment, slightly elevated above the surface film. It spends much of the time at the surface, but occasionally makes excursions to the bottom, especially when disturbed, moving by vigorous contortions of the body. It grows in size, and molts. When several days old it becomes very active, going often to the bottom in search of an abundance of food. After several molts and when 10 to 15 days old and about 5 millimeters long, the larva transforms into a pupa, quite different in form, more consolidated and resembling in shape the adult fly's body. The head and thorax are joined and rather swollen; the abdomen is represented by a tail with swimming flaps. The breathing tubes are now on the back near the head, and the body assumes a position in the water which allows these to protrude through the surface film. The pupa is equally active, but as it does not feed it moves only when alarmed. In two days the mature form emerges, leaving its pupal case behind in the water. These mate, and the cycle is continued. Twelve rearings of this species, including many hundred individuals, gave the following records: Egg stage, 1 to 2 days (mostly 1 day); larval stage, 11 days; pupal stage, 1 to 4 days (mostly 2 to 3 days). This gives an average life cycle from deposition of eggs to adult free flying mosquito of 15 days. It was found (with all three species) that a scarcity of food in the aquaria extended the larval life, which could easily be produced to two or three months, without otherwise interfering with the normal development of the species. This species breeds in fresh as well as in muddy and contaminated water and is the typical mosquito of the mud puddle. It was found in perfectly fresh drinking water, in the more or less brackish water of the duck ponds, in the muddy water of ponds, pools, gutters, drains, and in water contaminated by fecal matter, soap, rubbish, and other extraneous matter; it was found in such small collections of water, in tin cans, cups of flowers, small puddles, that without renewal from some source, the quantity of water present could not withstand the losses of evaporation through the larval period; yet it is able to breed in all of these situations in spite of their disadvantages, provided its physiological activities are not interfered with.

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[1] Monograph of the Culicidæ. London, 1910, vol. 5, p. 383.

The larva (Pl. I, 2, 2a) can be recognized from the following description:

Length 5 to 6 mm. Dark grayish, head more or less black. Thoracic segments almost as wide as the head, behind the thorax body slenderer and tapering. Anal siphon also long and slender, 1.2 mm. in length, greatest width 0.3 mm. Head more or less cubical, eyes black, mouth brushes as usual. The antennæ are long, 0.5 mm., about one-third the length from distal end the shaft becomes constricted, and in the notch thus formed is set a tuft of hairs; beyond the constriction the shaft is much thinner, and at the tip also there are two or three hairs. The labial plate bears a number of spines. The thoracic and abdominal segments laterally bear tufts of hairs which are longer on the thorax. The last abdominal segment bears a conspicuous ventral brush and dorsally there is a tuft of five long hairs. The siphon has a pair of hair tufts at about half its length, another pair a trifle before, more than a third the length from the proximal end, another pair of small tufts less than a third the length from the distal end and a fourth small pair somewhat before these and moved to one side out of line. There is a row of 13 three to four toothed spines on the siphon extending from the proximal end to the first pair of tufts. The lateral comb on the penultimate segment consists of more than 30 plates.

Attention is called to the shape of the anal lobes in the pupa. (Pl. I, 3.)

The adult (Pl. I, 4) is described as follows: [1]

> Thorax brown, with two distinct dark lines on the denuded surface, covered with pale golden curved scales and with two more or less distinct bare parallel dark lines and three rows of dark bristles, ornamentation variable. Abdomen dark brown to black, with basal white or pale creamy curved bands and white lateral spots; venter white or yellow scaled. Legs dark brown; bases of the femora and coxæ pale, knee spot and sometimes the apex of the tibia with a faint yellow spot; ungues of the female equal and simple; in the male the fore and mid ungues are unequal and uniserrated, the hind equal and simple. Wings with the first submarginal cell longer and narrower than the second posterior cell, its stem variable in length, never less than one-quarter the length of the cell; posterior cross vein distant twice (or more) its own length from the mid cross vein.

In view of Dr. Graham's investigations, this species is believed to be the intermediate host of the sporozoan parasite causing dengue fever.

DAY MOSQUITOES.

The day mosquitoes (*Aëdes calopus* and (*Stegomyia*) *Aëdes scutellaris*) are essentially different in appearance from the night one, and the two would never be confounded. Between themselves there are some striking small differences which distinguish them at once. The white markings on the back (dorsum of thorax) of *Aëdes calopus* are in the form of a lyre, while the marking on the back of *Aëdes scutellaris* is a single white line running down the center. The immature forms also present microscopic differences. The comb in the larva of *Aëdes calopus* is composed of 8 teeth with trifid apices, while the pupa has anal lobes dentate margined. The comb of the *Aëdes scutellaris* larva is composed of 10 unidentate teeth, and the anal lobes of the pupa have hairy margins. The Stegomyia larvæ differ radically from the Culex larvæ in both structure and habits, so that all three species are readily distinguished in any stage of their existence.

The exact date of the introduction of the day mosquitoes is not established, but it is quite certain that they came much later than the culicine and, from all accounts, during the lifetime of some of the present generation.

The habits of the two day mosquitoes are very similar. They prefer clear fresh water; at least, they are found almost altogether, if in natural collections of water, in clear water, never in puddles or polluted water, and while they are found along with *Culex quinquefasciatus* in clear standing water in troughs and other artificial containers they are not found if the water in such containers has become foul or turbid. They are very common around habitations, where the larvæ are usually found in water butts, troughs, or other containers of rain water or uncontaminated faucet water. They are also found in permanent pools along stream beds in the gulches and in water holes in the mountains. The adult fly differs radically from the culicine in habits, since it is almost entirely a day flyer, while the culicine stalks out in the night and can not be induced to bite in the daytime. It is also largely found in dark and shady places; in the woods it rests on vegetation, biting viciously when disturbed; in houses it gets in the dark recesses of the room or its furniture and comes forth from these retreats to bite the exposed parts of the body as soon as one's presence is sensed.

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[1] F. V. Theobald. Monograph of the Culicidæ. London, 1901, vol. 2, p. 151.

The life history of the day mosquitoes is somewhat as follows: They lay their small, black, torpedo-shaped eggs (Pl. I, 5) singly to the number of 40 or 50 on the surface of water, or, according to Dr. H. W. Henshaw, who made careful observations on the mosquitoes here some years ago, on the sides of containers, a quarter of an inch or so above the surface, where the eggs will withstand considerable desiccation (before the rising water floats them off) without its interfering with their hatching. The eggs hatch in five or six days. The larvæ in the water are of very similar appearance to the culicine larvæ, except for the short siphon and untapering body. Their habits, however, are different. They feed very largely at the bottom of containers or along the sides, seem to seek the darkest recesses, and do not come as often to the surface to breathe. For this reason they are a rather difficult mosquito to collect. The larval development is usually completed at the end of from 15 to 20 days, when the larva transforms into a pupa. The pupal development occupies two days, and from the pupa emerges the adult free-flying mosquito, male and female, which mate and repeat the cycle.

AËDES SCUTELLARIS.

The distribution of (*Stegomyia*) *Aëdes scutellaris* as given by Theobald[1] is as follows: India, Ceylon, Upper Burma, Siam, Penang, Perak, Selangor, Singapore, Christmas Island, Amboina, North Borneo, Sarawak, Celebes, British New Guinea and New Guinea generally, Foochow, etc., China, Hongkong, Formosa, Japan, Philippine Islands, Fiji, Pitcairn Islands, Seychelles, Mauritius, Guam (Fullaway).

Eight rearings of this species, including many hundreds of individuals, gave the following records: Egg stage 5 to 6 days, larval stage 15 to 24 days (one record 17 days, another 61 days [larval period protracted by reduction of food]), pupal stage 1 to 4 days (mostly 2 days).

It was found, as many other investigators have claimed, that permitting the adult to suck blood in some way accelerated the forma-

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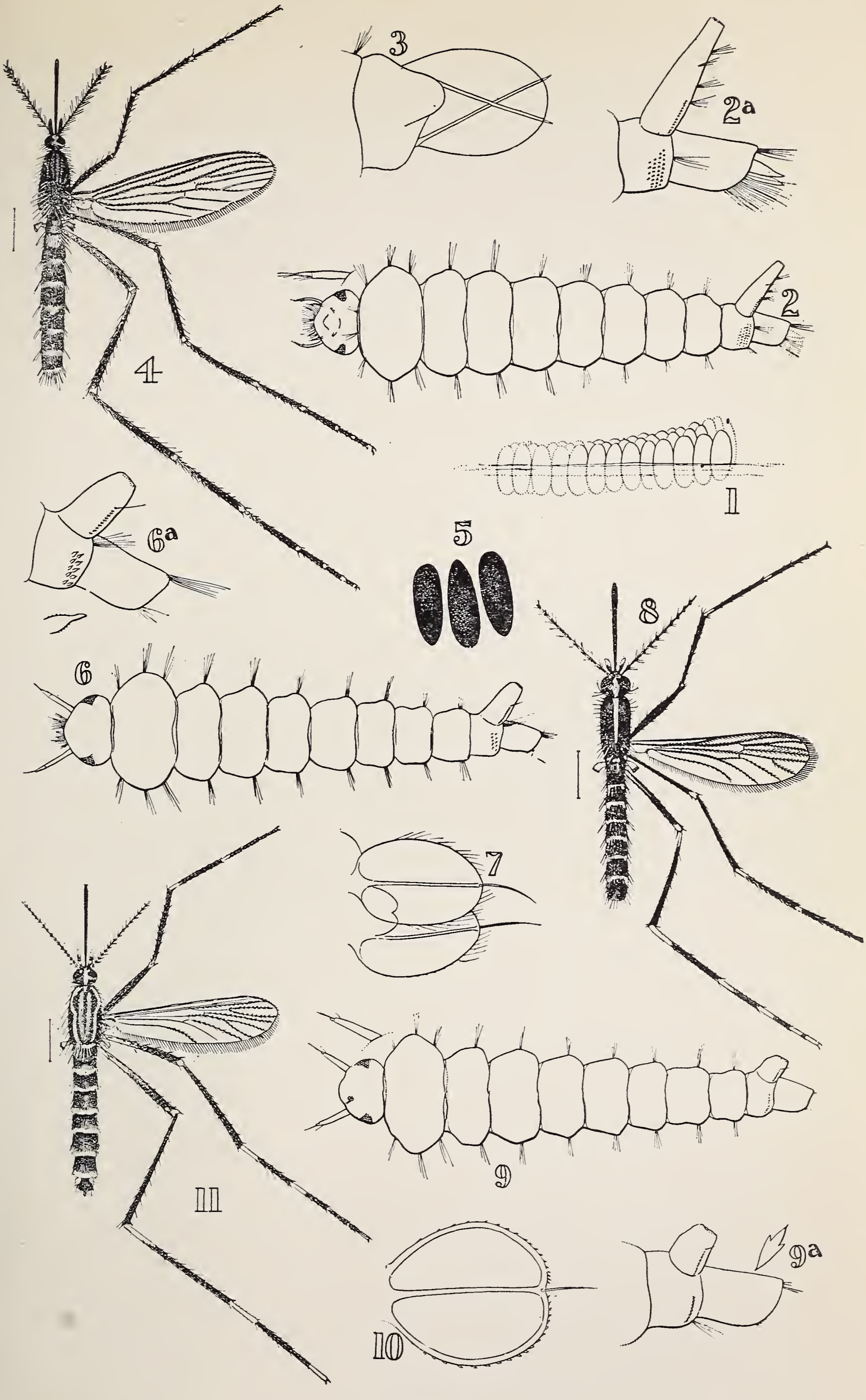
[1] Monograph of the Culicidæ. London, 1910, vol. 5, p. 155.



MOSQUITOES.

1, 2, 2a, 3, 4, eggs, larva, pupa, and adult of night mosquito; 5, eggs of day mosquitoes; 6, 6a, 7, 8, larva, pupa, and adult of *Aëdes scutellaris;* 9, 9a, 10, 11, larva, pupa, and adult of *Aëdes calopus.*

tion and deposition of eggs. All the specimens bred from egg to adult in the laboratory were allowed to feed previous to confinement, and none otherwise confined produced eggs. While this is not necessarily conclusive evidence as to the necessity of this performance to the production of eggs, it corroborates the observations of other workers and the idea seems altogether plausible.

Aëdes scutellaris, like the other mosquitoes in Hawaii, has a very general distribution, but out of the writer's experience the impression was gathered that it is the commoner of the two day-flying mosquitoes, and was always found in great abundance at the mouths of the numerous gulches behind the city of Honolulu in the belt of rising ground occupied by guava, lantana, and klu, where the larva breed in the pools formed by the receding water of drying-up creek beds, the adult flies finding shelter in the thick underbrush. It also breeds commonly around habitations on the outskirts of the city.

The larva (Pl. I, 6, 6a) can be recognized from the following brief description:

Length 6 mm. Grayish, head more or less dark. Thoracic segments almost as wide as the head, the body beyond scarcely tapering. Anal siphon moderately long, 0.72 by 0.36 greatest width. Head more or less cubical, eyes black, mouth brushes as usual, antennæ moderately long, tapering slightly, but of more or less uniform width throughout. A hair on the inner margin at about the middle and a stout spine and several hairs at the tip. Abdominal segments with a pair of hairs caudally on each segment. Ventral brush and dorsal tuft on ultimate segment thin. Pecten on anal siphon with 6 to 13 teeth in a row, the comb composed of 10 unidentate spines with small barbs at base.

Pupa (Pl. I, 7). The hairy margin of the anal lobes is peculiar.

The following brief description of the adult (Pl. I, 8) is sufficient to distinguish the species here:

Throax black, with a median silvery stripe; abdomen with silvery white basal bands; legs black, tarsi basally white banded, last joint of the hind legs pure white.

There is nothing in the literature of mosquitoes to warrant the statement that this mosquito is concerned in the transmission of yellow fever. Its distribution would apparently deny any such claim.

AËDES CALOPUS.

The distribution of *Aëdes calopus* as given by Theobald [1] is as follows: India, Upper Burma, Ceylon, Siam, ports in Malay Peninsula, Philippine Islands, Celebes, New Guinea, Java, Japan, Hawaiian Islands, Fiji, Pitcairn Islands, Samoa, generally in Africa, Southern United States, Mexico, Central America, Panama, west coast of South America, British and French Guiana, Trinidad, Brazil, West Indies, Southern Europe in Portugal, Italy, Spain, Gibraltar, Teneriffe, Greece, Cyprius, Australia in Queensland and Victoria, etc.

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[1] Monograph of the Culicidæ. London, 1910, vol. 5, p. 158.

Three rearings of this species, including many individuals, gave the following records: Egg stage, 4 days; larval stage, 17 days; pupal stage, 2 to 3 days.

This species is more or less rare; at least, in the writer's experience, it is not nearly so abundant as either *Aëdes scutellaris* or *Culex quinquefasciatus.* It was found chiefly around habitations, breeding in artificial containers of rain water or uncontaminated faucet water. Dr. Perkins states that on several occasions he found it in large numbers at rather high elevations, and the specimens on which it was first recorded from the islands were taken in the Waianae Mountains at 1,500 feet. Its distribution is therefore, like that of the other species, rather general, but it is not nearly so abundant as the other two species.

The larvæ (Pl. I, 9, 9a) can be recognized from the following description:

> Length 5 mm. Very similar to *Aëdes scutellaris.* The anal siphon, however, is short and thick, 0.72 mm. by 0.5 mm. greatest width, and its pecten is composed of 10 to 15 toothed spines. The lateral comb of the penultimate segment contains 8 plates with trifid apex arranged in a single slightly curved line.

Pupa (Pl. I, 10). The margin of the anal lobes is distinctly serrate and without hairs.

The following brief description from Theobald[1] will distinguish the adult (Pl. I, 11):

> Thorax dark brown to reddish brown, with two median parallel pale lines and a curved silvery one on each side, a small line in front between the two median ones. Abdomen black, with white basal bands and lateral spots. Legs black, with basal white bands, last joint of hind legs pure white.

The experiments of Maj. Walter Reed, United States Army, in Cuba, proved conclusively that this species is responsible for the transmission of yellow fever, probably acting as the intermediate host of an ultramiscroscopic parasite which produces the disease.

NATURAL ENEMIES OF MOSQUITOES.

There are no known specific parasites of mosquitoes. Among the natural enemies of these insects, which by feeding upon them tend to reduce their numbers, the most efficient are dragon flies and fish. There are several species of dragon flies in Hawaii which as nymphs prey upon the larvæ and pupæ in the water, and as mature free flying insects prey upon the imago or adult mosquito. Among the native fish which feed upon mosquitoes are the different species of gobies, locally known as oopu, which are found in all the streams and small ponds. There are also in Hawaii the introduced gold fish, which is very useful in aquaria, watering troughs, tanks, and other artificial pools containing more or less clear water, and the top minnows (Pœciliidæ), which were introduced some years ago from Texas for the specific purpose of destroying mosquito larvæ. The latter fish have proved very efficient mosquito enemies and along with the dragon flies effectively control the production of mosquitoes in the large low areas near the sea which are devoted to rice and taro growing or covered with the usual swamp vegetation. As the cultivated fields are frequently drained, they must often be restocked with fish. The fish, too, are often checked by the choking up of waterways and in these isolated bodies of water mosquitoes can develop with perfect freedom.

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[1] Monograph of the Culicidæ. London, 1901, vol. 1, p. 289.

REPRESSION OF MOSQUITOES.

Experience has shown that it is economically possible by well-directed efforts to destroy large numbers of mosquitoes in their aquatic stages and considerably lessen their annoyance. The method universally followed is to remove or treat the bodies of water in which the mosquitoes are found to breed. The unlimited details of anti-mosquito work have their foundation and beginning in the accomplishment of this simple purpose. It usually, however, becomes apparent in any work of this sort that many breeding places of mosquitoes have a very temporary existence and are constantly being obliterated, renewed, or altered—such breeding places, for instance, as tin cans, flower cups, or mud puddles—and that these breeding places require constant and continuous attention to effect any real benefit. This militates greatly against the value of sporadic campaigns against mosquitoes. The almost prohibitive expense of the repetition of work which could be done once for all time also enhances the value of permanent drainage of large bodies of water. If future work of this sort is attempted in Honolulu it is respectfully suggested to the public and its authorized agents that part of the funds be set aside for continuous permanent work, such as drainage and reclamation of lowland, rice fields, taro patches, etc.; that ordinances be secured making the maintenance of bodies of standing water in which mosquitoes might breed on premises a nuisance whose continuance would be punishable by fine; and that the funds not used in permanent or absolutely necessary emergency work be conserved to provide for a regular and continuous force of inspectors which would attend to the enforcement of the law as to owners and lessees of premises and look after the otherwise unattended territory to remove all possible breeding places of mosquitoes.

PINK BOLLWORM OF COTTON.

Some attention has been given to the pink bollworm (*Gelechia gossypiella*), which is now recognized as an important factor in the successful production of cotton in Hawaii. A great deal was expected of the cultural methods of control, but after the second year's trial the results seem only partially assuring, where the time and amount of rainfall is variable. One field of Sea Island cotton cut back in December was again in full flower in February and became so badly infested by bollworm that it was necessary to plow up and burn it to save adjacent fields.

In a bulletin[1] of this station the writer recorded the braconid, *Chelonus blackburni*, as a parasite of this species. Several new records are now offered. In a lot of infested bolls brought in in December there were found numerous specimens of a bethylid, believed to be [*Goniozus*] *Parasiorola cellularis*, presumably coming from larvæ of the bollworm. To determine the suspected relationship specimens were confined in breeding jars with larvæ of *G. gossypiella*, and after a short time the bethylid proceeded in its customary manner to paralyze the gelechiid larva and lay eggs upon it. Several generations of the parasite were bred and the length of the several stages noted, as follows: Egg stage 1 day, larva 7 days, pupa 11 days, making the cycle from egg deposition to adult parasite 19 to 20 days. From one to eight eggs were laid on a single caterpillar, but all did not mature. The larvæ usually feed externally, making large holes in the body of the worm, and the development is rather rapid. When full fed they make a small white elongate cocoon (usually spun in clusters where the larvæ were feeding) in which they pupate.

From the same lot of larvæ there were also bred several specimens of the ichneumonid, *Pristomerus hawaiiensis*, previously reported from the sweet potato stem borer (*Omphisa anastomosalis*), and from pupæ, a chalcid, probably belonging to the genus Hockeria, which has not previously been recorded in Hawaii.

The parasitism of all these species is apparently incidental and of rather small extent.

BEAN WEEVILS.

It has long been recognized that the value of the kiawe bean (*Prosopis juliflora*) as a stock food would be greatly increased if the pods were finely ground so as to put the seeds, which are rich in protein, in a digestible condition. With the perfection of machinery for this purpose, the losses occasioned by the bean weevils (bruchids), the larvæ of which largely feed upon the seed, again become a matter of importance. There are now two species of weevils attacking the kiawe bean, *Bruchus prosopis* and *Caryoborus gonagra*—both introduced pests. The work of the former has been known for a long time and the insect is common on all the islands. The latter species was first noticed in 1908 in Honolulu. Since then it has spread over the lowlands of Oahu and has also been found on the island of Kauai, so that there is no reason to doubt that ultimately it will have the same general distribution as the earlier species.

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[1] Hawaii Sta. Bul. 18.

The kiawe bean weevils are more or less familiar insects, but a short account of their life history will probably not be superfluous. The eggs are laid singly on the pods, one female weevil laying many eggs successively over the pod. The eggs are pearly, later turning creamy white, short oval, convex, microscopically reticulate, with distinct margin. There is no definite distinction between the eggs of the two species, and probably they can not be told apart. Those of *C. gonagra* are slightly larger. The egg (of *B. prosopis*) hatches in 10 days. The larva, which is stout bodied, yellowish white with black head, immediately burrows into the pod, often from beneath, so that the exposed portion of the egg is not broken. Making its way through the pulp, the grub finally reaches a seed, eats out its contents, and moves on to another seed—and so on until after 18 to 20 days it is full grown and pupates. After a variable period, usually 10 to 12 days, the pupa transforms into an adult beetle. The complete life cycle therefore covers about 40 days. The two species have been found working together in a single lot of beans. The larvæ of both beetles before pupating make an exit hole for the adult beetle, leaving only a thin film of cortical tissue to be eaten or broken through. These in the case of *C. gonagra* are much more conspicuous on account of their larger size and the thinness of the film. *C. gonagra* larvæ also make a cocoon within which to pupate and usually remain inside the cocoon for 3 to 4 days after becoming fully mature. The adults are easily distinguished, as *C. gonagra* is nearly twice the size of *B. prosopis* and is reddish brown, whereas the latter is more or less grayish marked with black.

An attempt was made several years ago to introduce from Texas certain hymenopterous parasites of the bean weevils, which, if established in Hawaii, would materially reduce the losses occasioned by these insects. Several consignments were received from the southern field laboratories of the Federal Bureau of Entomology, out of which one species (*Heterospilus prosopidis*?) bred by the thousands, and was liberated in several widely removed localities. While it is probably too early to state conclusively that this species has not become established, after three years it has not been recovered, although each year material has been especially bred for this purpose. In the material from Texas, however, was a minute hymenopterous parasite to which little importance was attached at the time the consignments were received, but which has now become established and proves a most valuable check to the multiplication of the weevils. This parasite, which attacks the eggs of the bean weevils, formed a new genus and species of Trichogramminæ and was recently described by

A. A. Girault as *Uscana semifumipennis*.[1] The parasite has already become rather generally distributed, and with the movement of beans from one locality to another will undoubtedly in time be spread over all the islands. The value of this check on the bean weevils will be realized from the results of an examination of a lot of beans recently, in which over 25 per cent of the eggs were parasitized.

SCALE INSECT PARASITES.

In connection with the study of the scale insects (Coccidæ), some attention has been given to the hymenopterous parasites of these and related insects, and an attempt has been made to bring together the records of parasitism in this economically important group, so that they will be available for reference to economic entomologists. This work was greatly facilitated by the loan of specimens in the collections of the Hawaiian Sugar Planters' Experiment Station and of the Board of Forestry and Agriculture, and the writer's thanks are due Mr. E. M. Ehrhorn and Dr. R. C. L. Perkins for many valuable records and suggestions in the elaboration of the material. Two new genera and three new species in the collections are herewith described. The lists which follow the descriptions are intended to present an orderly arrangement of the parasite species with their host relationships, and a table at the end shows the extent of the parasitism of the different species.

APENTELICUS gen. nov.

Near *Pentelicus* Howard, but at once distinguished from that genus by the insertion of the antennæ near the middle of the face. Body short, compact; abdomen small and triangular. Head transverse, lenticular, but not to the extreme degree seen in *Blepyrus*. Front fairly broad, with small thimble-like punctures, face wide, not retracted as in other genera, with rather broad longitudinal carina. Ocelli forming an obtuse triangle, the lateral members a trifle more than their diameter from the eye margin. Antennæ filiform, the broadly expanded scape short, not reaching ocelli; pedicle short, obconic, club not longer than the two preceding funicle joints. Punctuation of the thorax different from that of the head, very feeble. Marginal vein of wings short, less than twice as long as wide, postmarginal and stigmal veins rather short, subequal in length.

Type. The following species:

A. kotinskyi sp. n.

♂. Length of body, 1.17 mm., expanse of wings, 2.43 mm., greatest width of forewing, 0.47 mm. Head on vertex a brilliant metallic green with aeneous reflections, face and cheeks bluish green, eyes and occiput almost black. Ocelli reddish, mandibles brown, palpi yellow, antennæ sordid pale brown. Pronotum and mesonotum with axillæ metallic green, scutellum, mesopleuræ, and abdomen green with bluish reflections, legs pale brown. Body not especially stout, rather completely clothed with short white hairs. Thimble-like punctures on front of head extending on to vortex. Eyes small, widely separated. Antennæ 9-segmented (club undivided), long, filiform, extremely pilose, pedicle less than half the length of first funicle joint, funicle joints elongate, first more than twice as long as wide, club small, inconspicuous. Thorax scarcely convex, microscopically reticulate, feeble punctures of mesonotum arranged in more or less definite longitudinal rows, each puncture the point of insertion of a short white hair; scutellum shagreened with a few long hairs apically; mesopleuræ bare. Inner angles of the axillæ widely separated. Abdomen flat, short, acutely pointed at apex, with rather sparse vestiture of very short hairs and two lateral tufts of long hairs basally. Legs fairly stout, shortly and densely pilose. Wings hyaline, marginal vein short, postmarginal vein about as long as stigmal, which is fairly well developed.

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[1] Trans. Amer. Ent. Soc., 37 (1911), No. 1, p. 22.

Hab. Honolulu, Hawaiian Islands. Bred from *Lepidosaphes* sp.?

Adelencyrtus odonaspidis sp. n.

Length, 1.17 mm., wing expanse, 2.25 mm., greatest width of forewings, 0.33 mm. Metallic green, the face, genæ, prothorax, mesopleuræ, metathorax, and abdomen with purplish reflections. Head with face retracted below the eyes and lying in the dorso-ventral plane, posteriorly widening to the genæ, which are also well developed. Eyes black, hemispherical, the inner margins almost parallel, but rather widely separated; scrobes semicircular, inner margins forming a well defined carina. Fronds sparsely punctate, bearing whitish hairs; ocelli red and arranged in a triangle, the lateral members close to eye margin. Antennæ brown, basal joint of club dark; 11-jointed, arising not far from mouth border, the scape clavate, reaching anterior margin of face, pedicle obconic, longer than the following four submoniliform funicle joints, two remaining joints of funicle larger, almost quadrate, club somewhat expanded and almost as long as funicle. Prothorax well developed and anteriorly conically produced. Mesonotum flat and with mesopleuræ microscopically reticulate, the former bearing regular longitudinal rows of black hairs. Axillæ narrow, indistinctly meeting at the middle and with the triangular scutellum, which is nearly as long as the mesonotum, shagreened. Metanotum and abdomen smooth, the latter dorsally rather flat, collapsing after death, apex produced to a point. Fore and mid legs pale brown, hind femora black except at base, the hind tibia basally with black annulus. Ovipositor slightly exserted, brown. Wings fuscous with a hyaline band just beyond stigma and an oblique hairless line extending inward from same. Veins black, marginal vein obscured by infuscation but quite long, stigmal vein very short and thick, postmarginal still shorter.

Distinguished from other species in the genus by infuscation of wings.

Hab. Honolulu, Hawaiian Islands. Described from several specimens bred from *Odonaspis graminis* and given by Ashmead the manuscript name of *Amicroterys kotinskyi*.

PTEROPTRICHOIDES gen. nov.

Belongs in the same category as *Pteroptrix* but antennal and wing characteristics are essentially different. Head slightly produced in front and excavated below eyes for insertion of antennæ; ocelli forming an obtuse triangle, the lateral members close to eye margin; antennæ 8-jointed, inserted below the middle of the face, scape long, only slightly swollen, pedicle obconic, less than one-third as long as scape, funicle joints wider than long, the middle one the smallest and only half as long as wide, the entire funicle only a little longer than the pedicle, club large, elongate, joints subequal and fluted, gradually narrowing to a point at apex. Thorax convex, pronotum inconspicuous, mesonotum and scutellum forming a broad carapace, mesoscutar parapsides wedge-shaped, posteriorly very narrow, and much pressed by the advancement of the almost quadrate axillæ. Abdomen short, completely sessile, rounded at apex, ovipositor with prominent, long, thin, flat valves slightly exserted, and extending upward almost to the level of the dorsum. Legs stout, all the tarsi 4-jointed. Forewings with long marginal fringe and sparse discal ciliation, the marginal vein almost as long as the submarginal, the tip reaching middle of wing. Hind wings narrow, with long marginal fringe and short discal cilia; marginal vein ending at middle of wing, which is there somewhat produced anteriorly.

Type. The following species:

P. perkinsi sp. n.

Length, 0.7 mm., expanse of wings, 1.34 mm., greatest width of forewings, 0.2 mm. Color in balsam dark brown, eyes black, ocelli red, legs pallid. Occiput finely aciculate, the aciculation extending on to vertex, which also bears a few sparse hairs. Forewings clouded basally to apex of the marginal vein, which is thick, ending at middle of wing. Stigmal vein entirely undeveloped.

Hab. Honolulu, Hawaiian Islands. Bred from a coccid (n. g. and n. sp.) on Bombay mango by Mr. Jacob Kotinsky, August 24, 1906.

List of parasites and their hosts.

CHALCIDOIDEA.

ENCYRTIDÆ.

Ectromini.

Parasites.	Hosts.
Anagyrus sp.?	*Pseudococcus* sp.

Encyrtini.

Encyrtus fuscus	*Saissetia hemispherica.*
Encyrtus sp. (with banded ant.)	*Saissetia* sp.
Encyrtus sp	*S. hemispherica.*
	Coccus viridis.

Mirini.

Blepyrus insularis	*Pseudococcus aonidum.*
	P. virgatus.
Aphycus sp.?	*P. calceolariæ.*
Aphycus sp.?	*Lepidosaphes* sp.
Microterys flavus	*Pulvinaria mammæ.*
	P. psidii.
	Ceroplastes rubens.
	Saissetia hemispherica.
	S. nigra.
Apentelicus kotinskyi	*Lepidosaphes* sp.
Adelencyrtus odonaspidis	*Odonaspis graminis.*
Cerapterocerus sp	*Saissetia hemispherica.*
	Aspidiotus sp.?
Hemencyrtus sp.?	*Saissetia nigra.*
Aphidencyrtus sp.?	*Aphis maidis.*
Encyrtus sp.?	*Pseudococcus citri.*

PTEROMALIDÆ.

EUNOTINÆ.

Scutellista cyanea	*Saissetia hemispherica.*

SPHEGIGASTERINÆ.

Tomocera californica	*Asterolecanium pustulans.*
	Saissetia hemispherica.
	S. nigra.
T. ceroplastis	*Ceroplastes rubens.*

EULOPHIDÆ.

ENTODONINÆ.

Astichus sp	?

APHELININÆ.

Aneristus ceroplastæ	*Ceroplastes rubens.*
Coccophagus orientalis	*Pseudococcus* sp.
	Coccus viridis.
Coccophagus lecanii	*Aspidiotus rapax.*
Encarsia sp	*Aleyrodes sonchi.*
Thysanus sp	*Asterolecanium pustulans.*
	Aspidiotus cydoniæ.
Aphelinus diaspidis	*Diaspis bromeliæ.*
	Aulacaspis rosæ.
	Hemichionaspis minor.
	Aspidiotus camelliæ.
Aphelinus sp. (wingless)	*Lepidosaphes* sp.
Pteroptrichoides perkinsi	Coccid (n. g., n. sp.) [Kot.].
Pteroptrichoides sp	*Asterolecanium pustulans.*
	Howardia biclavis.
Aspidiotiphagus citrinus	*Hemichionaspis minor.*
	Chrysomphalus aonidum.
Eretmocerus corni	*Aleyrodes hibisci.*

ICHNEUMONOIDEA.

BRACONIDÆ.

APHIDIINÆ.

Diaeretus rapæ	*Aphis brassicæ.*
	Macrosiphum sp.

CYNIPOIDEA.

FIGITIDÆ.

EUCOILINÆ.

Eucoila sp.?	*Macrosiphum* sp.
	Aphis sacchari.

List of hosts and their parasites.

COCCIDÆ.

DACTYLOPIINAE.

Hosts.	Parasites.
Asterolecanium pustulans	*Pteroptrichoides perkinsi.*
	Thysanus sp.
	Tomocera californica.
Pseudococcus aonidum	*Blepyrus insularis.*
P. calceolariæ	*Aphycus* sp.
P. citri	*Encyrtus* sp. (Mirine).
P. virgatus	*Blepyrus insularis.*
Pseudococcus sp	*Coccophagus orientalis.*
Pseudococcus sp	*Anagrus* sp.?

COCCINÆ.

Pulvinaria mammæ	*Microterys flavus.*
P. psidii	*M. flavus.*
Ceroplastes rubens	*Aneristus ceroplastæ.*
	Microterys flavus.
	Tomocera ceroplastis.
Coccus viridis	*Coccophagus orientalis.*
	Encyrtus sp.
Saissetia hemispherica	*Microterys flavus.*
	Tomocera californica.
	Scutellista cyanea.
	Cerapterocerus sp.?
	Encyrtus fuscus.
	Encyrtus sp.
Saissetia nigra	*Hemencyrtus.*?
	Microterys flavus.
	Tomocera californica.
Saissetia sp	*Encyrtus* sp. (with banded ant.).

DIASPINÆ.

Howardia biclavis	*Pteroptrichoides* sp.
Diaspis bromeliæ	*Aphelinus diaspidis.*
Aulacaspis rosæ	*A. diaspidis.*
Hemichionaspis minor	*A. diaspidis.*
	Aspidiotiphagus citrinus.
Aspidiotus excisus	?
A. camelliæ	*Aphelinus diaspidis.*
A. cydoniæ	*Thysanus* sp.
A. rapax	*Coccophagus lecanii.*
Aspidiotus sp	*Cerapterocerus* sp.
Chrysomphalus aonidum	*Aspidiotiphagus citrinus.*
Odonaspis graminis	*Adelencyrtus odonaspidis.*
Lepidosaphes beckii?	*Aphycus* sp.
Lepidosaphes sp	*Apentelicus kotinskyi.*
	Aphelinus (wingless).

ALEYRODIDÆ.

Aleyrodes hibisci	*Eretmocerus corni.*
A. sonchi	*Encarsia* sp.

APHIDIDÆ.

Macrosiphum sp	*Eucoila* sp.?
	Diæretus rapæ.
Aphis maidis	*Aphidencyrtus* sp.?
A. gossypii	*Aphelinus diaspidis.*
A. brassicæ	*Diæretus rapæ.*

The host relationship of scale insect parasites.

Parasites.	*Asterolecanium pustulans.*	*Pseudococcus aonidum.*	*P. calceolariæ.*	*P. citri.*	*P. virgatus.*	*Pseudococcus* sp.	*Pseudococcus* sp.	*Pulvinaria mammæ.*	*P. psidii.*	*Ceroplastes rubens.*	*Saissetia hemisphærica.*	*S. nigra.*	*Saissetia* sp.	*Howardia biclavis.*	*Diaspis bromeliæ.*	*Aulacaspis rosæ.*	*Hemichionaspis minor.*	*Aspidiotus camelliæ.*	*A. cydoniæ.*	*A. rapax.*	*Aspidiotus* sp.	*Chrysomphalus aonidum.*	*Odonaspis graminis.*	*Lepidosaphes beckii.*	*Lepidosaphes* sp.	*Aphis maidis.*	*A. brassicæ.*	*Macrosiphum* sp.	*Aleyrodes sonchi.*	*A. hibisci.*
Anagyrus sp						×																								
Encyrtus fuscus											×																			
Encyrtus sp				×																										
Encyrtus sp											×																			
Encyrtus sp											×																			
Blepyrus insularis		×			×																									
Aphycus sp			×																											
Aphycus sp																									×					
Microterys flavus								×	×	×	×	×																		
Apentelicus kotinskyi																									×					
Adelencyrtus odonaspidis																							×							
Cerapterocerus sp											×										×									
Hemencyrtus sp												×																		
Aphidencyrtus sp																										×				
Scutellista cyanea											×																			
Tomocera californica	×										×	×																		
T. ceroplastis										×																				
Aneristus ceroplastæ										×																				
Coccophagus orientalis							×																							
C. lecanii																				×										
Encarsia sp																													×	
Thysanus sp	×																		×											
Aphelinus diaspidis															×	×	×	×												
Aphelinus (wingless)																									×					
Pteroptrichoides perkinsi	×													×																
Aspidiotiphagus citrinus																	×					×								
Erctmocerus corni																														×
Diaeretus rapæ																											×	×		
Eucoila sp																												×		

NOTES ON BREEDING AND IMMATURE STAGES OF COCCINELLIDÆ.

Some work has been done on the identification of the immature forms of the different species of coccinellid beetles, which have considerable interest as enemies of the scale insects, leaf hoppers, plant lice, white flies, etc. The life history of three species has been fully worked out, and the data, together with some miscellaneous notes on these insects, are here presented.

Coelophora inequalis.—This species, which was formerly known by the name of *Coccinella repanda*, has been shown by Dr. Perkins and others to be quite distinct from that species and is now definitely known to be the above. An account of its life history is presented by Swezey in a bulletin of the Hawaiian Sugar Planters' Station.[1]

Coelophora pupillata.—Eggs elongate oval, 1 mm. long, chrome yellow, laid on end on the surface of a leaf in clusters of 5 to 10 or more.

Larva when hatched, 2 mm. long, similar in shape to young larva of *C. inequalis.* Dusky black, white spot laterally on first abdominal segment and a transverse band of white on fourth abdominal

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[1] Hawaiian Sugar Planters' Sta., Div. Ent. Bul. 1, pt. 7, p. 228.

segment. A white line down center of thorax and abdomen to the band on fourth segment. Legs black.

Molts four times previous to pupation.

Full-grown larva shining black with the following markings: A thin line on anterior margin of prothorax and an inverted V-shaped wedge on posterior margin medially; on mesothorax laterally and an inverted V-shaped marking medially reaching anterior margin, same on metathorax, white; orange spot laterally on first abdominal segment and orange band on fourth abdominal segment; median and four lateral longitudinal lines traversing the entire abdomen, white, as also the hind margin of segments 7 and 8. Legs strong and conspicuous. Venter fuscous. 8.5 mm. long.

Pupa like that of *C. inequalis.*

	Days.
Egg stage	3 to 4
Larval stage	15 to 21
Pupal stage	7

Platyomus lividigaster.—The name Pseudoplatyomus is suggested for Platyomus, which is preoccupied in Rhyncophora.

Eggs elongate oval, very small, 0.75 by 0.35 mm., yellowish to brownish, laid in numbers (15 to 20 or more) on their sides on surface of leaf.

Larva when hatched 0.75 to 1.5 mm. long, yellowish brown, with a longitudinal row of fuscous tubercles on either side near margin. Legs fuscous.

Four molts previous to pupation.

Full-grown larva 5 mm. long, reddish brown with longitudinal rows of tubercles as in immature larva. Head fuscous, tubercles white at apex, fuscous at base and surrounded with black on meso- and metathorax and abdominal segments 5 to 9. Legs blackish. Waxy secretion ventrally on thorax and first four abdominal segments.

Pupa reddish yellow mixed with black. Length 3.5 mm., width 2.5 mm., depth 2 mm. Attached by posterior end. Ventrally flat, dorsally convex and carinated. A faint median and two more pronounced lateral longitudinal carinæ. Three conspicuous spines immediately in front of middle, almost entirely covered with white waxy secretion. In pupating the larva rotates its body around the point of attachment, at the same time depositing a thin film of white waxy secretion.

	Days.
Egg stage	3 to 4
Larval stage	7
Pupal stage	5 to 6

Scymnus notescens.—Eggs flat, 0.63 by 0.41 mm., oval or irregular in outline, slightly convex above, ochraceous, finely punctured. Many eggs laid singly on leaf or stem.

Larva when hatched 0.75 mm. long, elongate oval, rather flat, sordid white to greenish black, a black protuberance bearing two hairs laterally on each segment, forming a marginal fringe. Head black, truncate, two large black bars on first thoracic segment, remaining thoracic segments white. Indistinct dark spots and dark line to fourth abdominal segment. Whitish capitate hairs in longitudinal lines on dorsum, four on either side.

Full grown larva 3.5 mm. long, nearly 2 mm. wide, long oval, only slightly convex, head small, labelliform and retractile, prothorax distinctly constricted from the rest of the body, flat above and carapace-like, subquadrate, anteriorly and laterally, with a fringe of very fine hairs. Segments of body rather indistinctly marked, a lateral protuberance on meso- and metathorax and abdominal segments 1 to 8, forming a fringe, each protuberance bearing fine white setæ. Anal segment with caudal fringe of fine white hairs, fine hairs on each side. A transverse line of small white setæ and many scattered hairs on each segment behind head. Color yellowish brown, with a median and two lateral lines fuscous to dark brown, the head and legs outwardly also fuscous to dark brown, basally yellowish, a pale yellow spot on mesothorax and one on anterior margin of metathorax, the prothoracic shield with a median light line separating darker areas, pale again on lateral margin. Lateral protuberances almost black, ultimate segment with median black spot. Venter yellowish brown.

Pupa oval, more or less truncate anteriorly and posteriorly and quite convex. Attached caudally. Head beneath prothoracic carapace forming anterior end of body, wing covers reaching beyond second abdominal segment, laterally to fourth abdominal segment, tips reaching posterior margin. Body covered with whitish hairs. A median longitudinal carina on abdomen dorsally brownish, the prothoracic carapace and last abdominal segment blackish, a median light yellow line on metathorax and abdominal segments. Legs black.

	Days.
Egg stage	1 to 2
Larval stage	10
Pupal stage	5

MEDITERRANEAN FRUIT FLY.

The predictions made in regard to the harmful nature of this fly have been fully justified by the experience of the past year. With optimum conditions for its development and practically no natural checks, the fly has increased with astonishing rapidity, and with the clandestine movement of fruit from one island to another, has spread to and become firmly established in all the principal islands of the group. The fly has shown a wide range of adaptability to different kinds of fruits, and from the six or seven fruits mentioned in the last annual report as attacked by this pest the list of infested fruits has swollen to the extent of including nearly every fruit with soft pulp in the islands. With many of these fruits, however, the infestation is largely incidental, and there is an undoubted preference shown for peaches, coffee berries, citrus fruits, and kamani seeds.

Little has been actually accomplished in the way of controlling the fly and little can be done under the peculiar conditions existing here, with large areas of uncultivated land and forest supporting a wild growth of fruit-bearing trees, shrubs, and herbs in which the fly can maintain itself in spite of all efforts at artificial control. In circumscribed areas, where the protection of valuable edible fruits made it seem desirable to attempt its control, the commonly recognized methods, such as destruction of infested fruit, spraying, or poisoned bait, and trapping with kerosene, have been tried with fair success. By these methods the fly is reduced to a minimum during the winter months, but with the approach of summer and the appearance of the heavy fruit crops the expense of an adequate control becomes almost prohibitive and the work is surrounded by many almost insurmountable difficulties.

The spread of the fly to the Kona coffee fields for a time produced alarm, but it has not yet been demonstrated that the fly affects the coffee bean in any way or causes any great loss in connection with the crop. The dropping of immature berries, which has been partly ascribed to the fly, is a usual occurrence and may be due to several causes. The fly's part in it is obscured by the phenomenally large crop of the present year.

MISCELLANEOUS WORK.

Some attention has been given to beekeeping and certain aspects of the industry are being carefully studied. During the year two papers on insects have been prepared for publication, one on the insects attacking the avocado in Hawaii, the other on the insects attacking the pineapple.

REPORT OF THE HORTICULTURIST.

By J. Edgar Higgins.

The work of the horticultural department has proceeded along about the same lines as were indicated in the last annual report. The subjects which have received chief attention have been the avocado, the mango, the pineapple, and the papaya. Quite a number of noteworthy varieties of hibiscus have been originated by Mr. Valentine S. Holt, assistant in horticulture. Some attention has also been given to a number of miscellaneous subjects, as the treatment of bananas for shipping, a special method for pruning the peach in this climate, a brief survey of some of the results of onion growing on Kauai, together with assistance rendered at the Homestead substation on Kauai.

In addition to these lines of experiment and investigation, there has been a much larger amount than usual of construction work in progress. Under the immediate supervision of Mr. C. J. Hunn, assistant horticulturist, there have been erected a new insect-proof glass house, a shade house and potting shed, and a workshop and storeroom for horticultural purposes is just being completed. These buildings, together with several new insect-proof tables, add greatly to the equipment.

THE PINEAPPLE.

The most important present horticultural pursuit in Hawaii is pineapple growing. This industry has grown in a little more than a decade from an insignificant position in the activities of the Territory to a place second only to sugar production. The pack of canned pineapples for the present season is estimated at about 1,000,000 cases, valued at $3,000,000. The Hawaiian pineapple has gained a reputation in American markets in the form of fresh fruit and in the can. The canned product has found even a wider field and is being shipped to Europe and other foreign countries. The large demand has stimulated further plantings, and new companies or those already in the business have acquired leases during the year on several thousand acres of land not heretofore under cultivation. The Territorial government has opened for homesteading several tracts of land supposed to be well adapted to the pineapple, and these also will probably be planted chiefly to this crop. Indeed, it seems not improbable that the present output may be again doubled in the next few years.

How long the demand will keep ahead of the supply and to what extent the Hawaiian trade will be affected by the increasing output of Porto Rico, Cuba, or the Philippines are problems which some of the growers are studying. At present there is no slackening in the demand.

This extension of the pineapple area in Hawaii, and in particular on homestead lands, has given rise to a demand for information relative to the growing of the crop. This station has published from time to time several bulletins on specific phases of the subject, including problems connected with soils, insect pests, diseases, and the marketing of the fresh fruit. Nevertheless, many phases of the subject concerning which inquiry is frequently being made had not been touched upon in these publications, and an attempt has been made to meet this demand in part by a general bulletin from the horticultural division of the station on "The Pineapple in Hawaii." This bulletin [1] includes the results of a few recent investigations as well as a general statement of methods in practice in pineapple growing.

THE AVOCADO.

PROPAGATION.

The experimental work in the propagation of the avocado during the year has been concerned chiefly with the use of quite young seedlings. These have been used both as budding stock and for inarching. (Pl. II, fig. 2, B and C.)

For budding, the stocks have been grown either in nursery row or in containers, such as soy tubs, shingle boxes, ordinary earthen pots, and tin cans. The seeds may be germinated in these or in "ti" leaf pots.[2] Soy tubs from which the salt has been thoroughly washed are satisfactory for a few plants, particularly if they are to remain for some time without transplanting, but the tubs are entirely too large to be economical of space, soil, or transportation costs. They can be bought in quantity for 10 to 12 cents each. Boxes 6 to 8 inches square and about 10 inches high can be made of shingles at a cost of approximately 10 cents each, and these are large enough to carry the plants through until the buds are well established. An ordinary earthen flowerpot serves the purpose well but is more expensive, and if the plant is removed from it and packed for shipping there is greater danger of injury than in the case of a young tree in the container in which it has been grown. One-gallon round tin cans appear to be quite satisfactory. There are usually many of

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[1] Hawaii Sta. Press Bul. 36.

[2] Hawaii Sta. Bul. 25, p. 13.

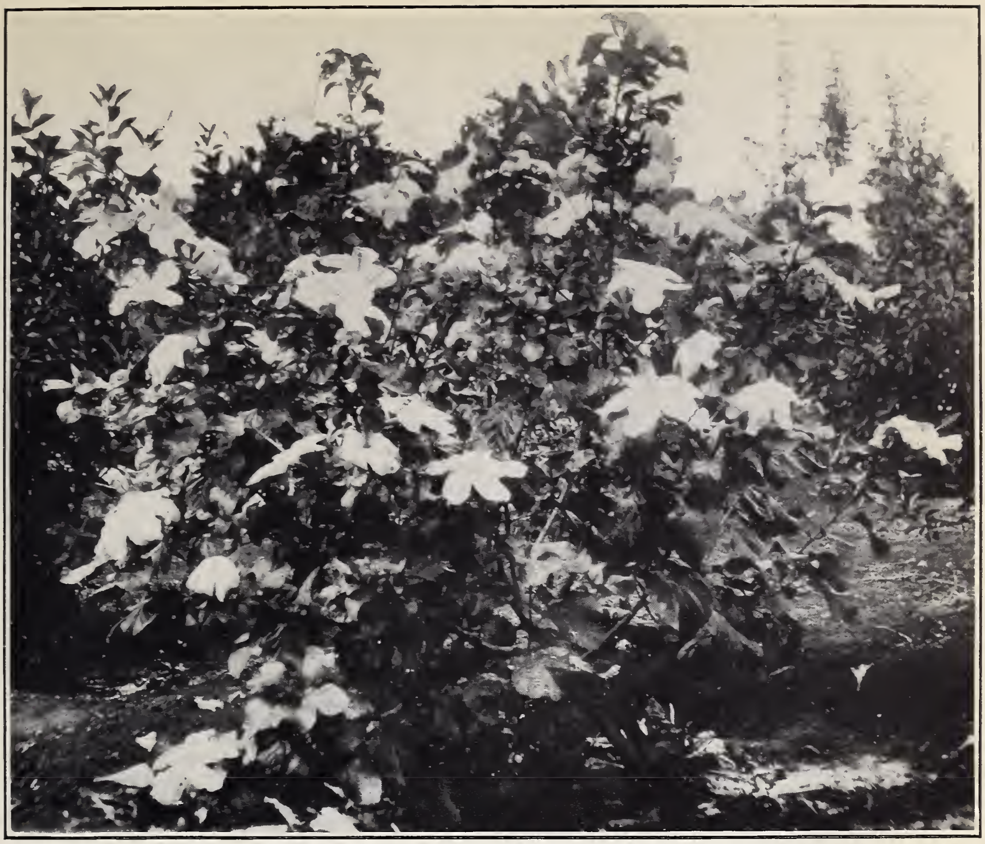

FIG. 1.—HIBISCUS, VARIETY RUTH WILCOX.

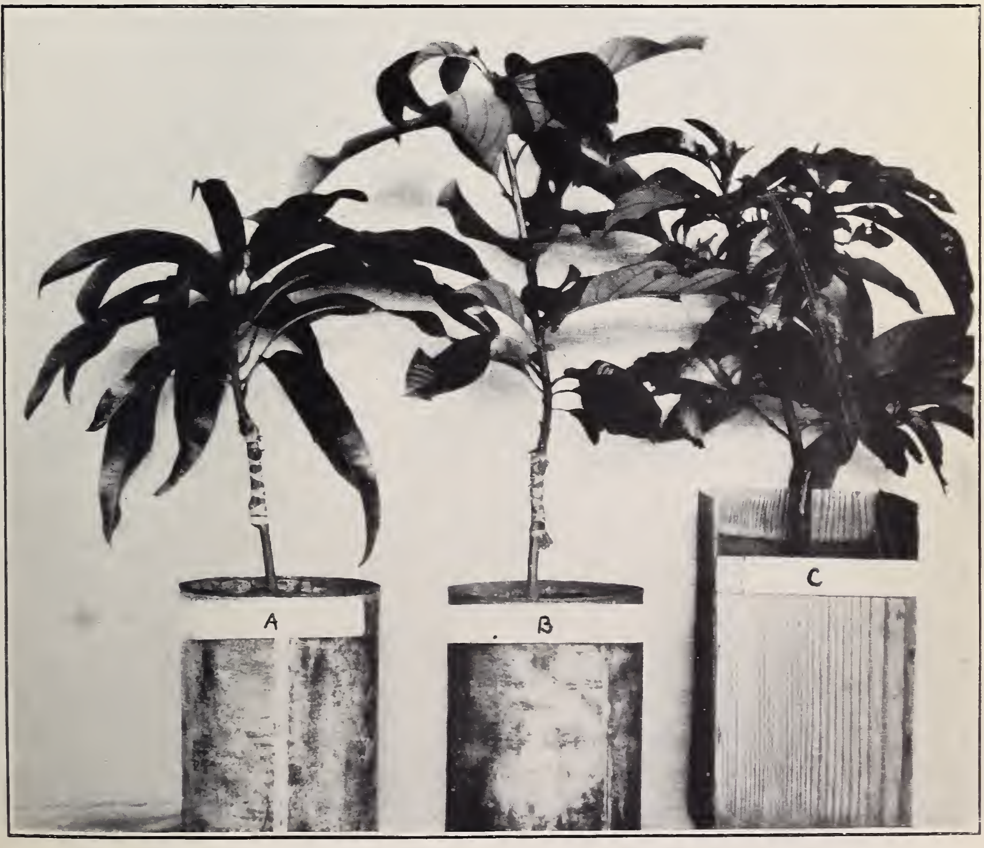

FIG. 2.—A YOUNG SEEDLING MANGO INARCHED; B, YOUNG SEEDLING AVOCADO INARCHED; C, YOUNG SEEDLING AVOCADO BUDDED.

these, more or less defective or damaged, that have been discarded at the pineapple canneries. If a cut is made with a can opener, nearly encircling the bottom, drainage is provided and the tree can be shipped in the can. Even when transplanting it is not necessary to take it out, since the bottom of the can may be bent back, affording an opportunity for the roots to get out. It is, however, an easy matter to cut the can on one side when the tree is in place and plant it without disturbing the root system in any way.

If placed in the nursery, the young plants should be about 18 inches apart in rows wide enough to permit of such implements of tillage as it is intended to use. Whether in pots or in the nursery, it is necessary to keep the seedlings in a healthy, rapidly growing condition. They may be budded when they are about five-sixteenths of an inch in diameter and will be ready for planting in garden or orchard in about a year from the germination of the seed.

Another means of shortening the time required in propagation has been the inarching of very young seedlings. For this purpose the seedlings are cared for in the usual way and when about five-sixteenths of an inch in diameter are transplanted to pots or boxes, placing the stem to one side rather than in the center so as to facilitate getting it into contact with the scion. A very convenient substitute for a pot has been suggested by Oliver.[1] This consists of a burlap wrapping. Burlap is cut in strips of suitable size to hold the plants and on this is placed a mixture of soil, sand, and sphagnum moss. The ball of soil surrounding the roots is placed upon this and the whole is wrapped and tied. The advantages of this device are that it is light, compact, and less clumsy than a pot and if necessary can be tied to a branch of the tree, thus eliminating the benches required to support pots. But even if the bench is used, as sometimes seems desirable, a great many more plants can be placed upon it in wrappings than in pots.

The inarching process for these very young seedlings is precisely the same as that for older plants and need not be further described here. It has been found advantageous to fertilize the seedlings about once in two weeks by the use of a small amount of fertilizer added to the water. In the case of avocados a union is effected in about six weeks.

Thus the avocado, which a few years ago was thought to be difficult or almost impossible of asexual propagation, is yielding to many methods of multiplication.

DISTRIBUTION.

By means of these experiments the station has at the same time been perpetuating a number of valuable varieties, some of which have been represented by a single specimen only and otherwise likely to become extinct. As there is no nursery in Hawaii where grafted or budded avocados can be secured, these plants are being distributed, a small charge being made for them.

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[1] U. S. Dept. Agr., Bur. Plant Indus. Bul. 202, p. 16.

One of the varieties which are now being sent out is of seedling origin and of the Guatemala type. It has been grown at the station and is worthy of being named, described, and distributed. This variety, which has been named the Nutmeg, is superior in some respects to its parent and has been described by Mr. C. J. Hunn, as follows:

> The Nutmeg avocado. Fruit from the original avocado tree of the Guatemala or "hardshelled" type [1] was collected in December, 1907. A seedling grown from this seed was placed in the orchard on March 17, 1908. This tree came into bearing in December, 1911, four years from seed.
>
> Form roundish to spherical, size medium; cavity small, shallow, and flaring; stem short and inclined to be thick; surface undulating, very hard; coriaceous and markedly pitted; color greenish purple to black with very abundant, irregular-shaped yellowish dots; apex a mere dot, slightly depressed; skin very thick and woody, separating fairly well from the pulp; flesh yellow in color, running into green at the skin; fine-grained, a trifle juicy, oily and somewhat buttery, 68 per cent of the fruit; seed large, roundish, flattened at the base, fitting tightly in the cavity; flavor rich and nutty. Season late.
>
> This tree is quite vigorous and is pyramidal in shape. Height 15 feet, spread 8 feet. (Hunn.)

DISEASES AND INSECTS.

A new injury resulting from the fungus Glœosporium [2] has been observed. A number of the seedling inarches referred to above were found dying back from the wound made in cutting off the scion or the top of the stock. In the case of the budded seeedlings a similar decay was found, beginning at the wound where the stock was headed back and extending down so low as to cut off the supply of sap from the growing bud. It was suspected that these injuries were due to the fungus just mentioned and specimens were submitted to Mr. L. D. Larsen, of the Hawaiian Sugar Planters' Experiment Station, who reported the fungus present in each case examined. It has not been determined whether the infection is frequently made with the knife or merely results from exposure to the spores carried by the wind. In any case it seems best to protect the wounds with grafting wax or with some antiseptic covering. If it should appear that the knife is a potent factor in carrying the disease it may be best to disinfect the blade when using suspicious bud wood.

The wood-boring beetle, *Xyleborus immaturus*,[2] made its appearance in the station orchard during the year and has been much complained of in other parts of the city. This has been combated at the station by pruning and by the use of a wash composed of 1 gallon soft soap, 3 gallons water, and ½ pint crude carbolic acid. This was applied to the trunks and branches of all the trees with a whitewash brush. The treatment appears to have held the insects in check.

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[1] Hawaii Sta. Rpt. 1910, p. 28, No. 149; Bul. 25, p. 43.

[2] Hawaii Sta. Bul. 25, p. 23.

THE MANGO.

The grafting of very young seedlings of the mango has been tested along the same lines as practiced with the avocado and with equally good results. (Pl. II, fig. 2, A.) The mangoes are better to be a little older than the avocado because they do not so quickly acquire the desired diameter of stem and because most of the shoots of the mango trees which are to be used as scions are of considerable size. It has also been found necessary to allow the mango inarches eight or nine weeks to unite, this being at least two weeks longer than the avocado requires. The mangoes that have been thus propagated are chiefly of the Indian and other varieties introduced in recent years but include also some choice kinds that have originated here.

Distributions of these grafted mangoes are being made as indicated for the avocado. The varieties being thus distributed are as follows: Alphonse, Pirie, Oahu, and Smith.

Some interesting results are now available showing the time required for the bearing of budded mangoes. An old tree partly top-worked to the variety Pirie, in February, 1910, is bearing this year some fruit which will mature in about two and one-half years from budding. The varieties Smith and Java are requiring about two and one-fourth years and the Gay a little more than three years. The latter, however, was budded very late in the season (May 24) and did not have the advantage of the best season of growth, which is from December to May. These results would suggest that trees budded in December or January may be expected to produce some fruit in about two years from the following June and July, these months being the mango fruiting season.

There are fruiting at the station this summer, but not mature enough for describing at the date of this writing, the following varieties: Brindabani, Totafari, Gay, Java, Wootten, Bennett Alphonse, Alphonse, Divine, Pirie, and Smith.

The mango is being very seriously attacked by the Mediterranean fruit fly, *Ceratitis capitata*, and it has been necessary to cover with cotton bags the fruits of many of the varieties. Although several fruits can be placed within one bag, the practice is tedious and expensive. Nevertheless, it is well worth the trouble in the case of the best varieties. Fortunately, not all varieties are equally susceptible, some being quite resistant. It can not be stated that there are any which are immune from the attacks of this fly, but no infestation has yet been found on the Brindabani, although the fruits are not ripe at this time and may be attacked later. The Smith and several of the Cambodiana type, locally known as "Chutney" varieties, appear to be attacked only slightly, and chiefly when the fruit is very ripe. By picking the mangoes of these kinds before they have begun to soften the fly can be avoided to a considerable degree. Too much confidence should not be placed in these habits, for there are many other varieties upon which the maggots may feed, and if these were not in fruit the flies might deposit more eggs in the fruits which now show resistant qualities.

THE PAPAYA.

The papaya investigations have been continued along the lines indicated in the last two annual reports. There is little to report in the way of new conclusions, but some interesting data are developing. One of the questions which have naturally arisen in this study has been whether the monœcious or the diœcious type is the more primitive, and, further, as to the origin of the later type. There are now under observation a series of gradations between the two types which appear to indicate that the monœcious papaya has developed from the staminate tree of the diœcious type. It was stated in earlier reports that this staminate tree occasionally produces a perfect flower which matures a fruit.[1] There are now trees at this station bearing none, others bearing only a few, and still others producing no less fruits than many pistillate trees. One has 87 fruits upon it at this writing. These fruits and the flowers that produce them are of the general form of the monœcious type. If, then, the long peduncle upon which they are born be shortened, the result would be the ordinary monœcious papaya. A tree has been under observation in which these peduncles are midway in length between those of the monœcious tree and those of the so-called "staminate" tree which produces fruit. The observer might be in doubt whether to call this tree one of the monœcious type with extra long peduncles or a "staminate" tree producing an extraordinary number of fruits, for these differ apparently only in the number of the fruits and the length of the peduncles. There is also under observation a staminate tree with flower stems as short as those of any pistillate tree. Some of the gradations referred to are illustrated in Plates III and IV.

But even if this series of gradations approaches completeness sufficiently to justify the conclusion that there has been an evolution from the one type to the other, the further question arises, Are we justified in concluding that the process has been in the direction sug-

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[1] All staminate flowers of these trees have aborted pistils, but, with the exceptions mentioned, they do not possess a stigma, and can not produce fruit.

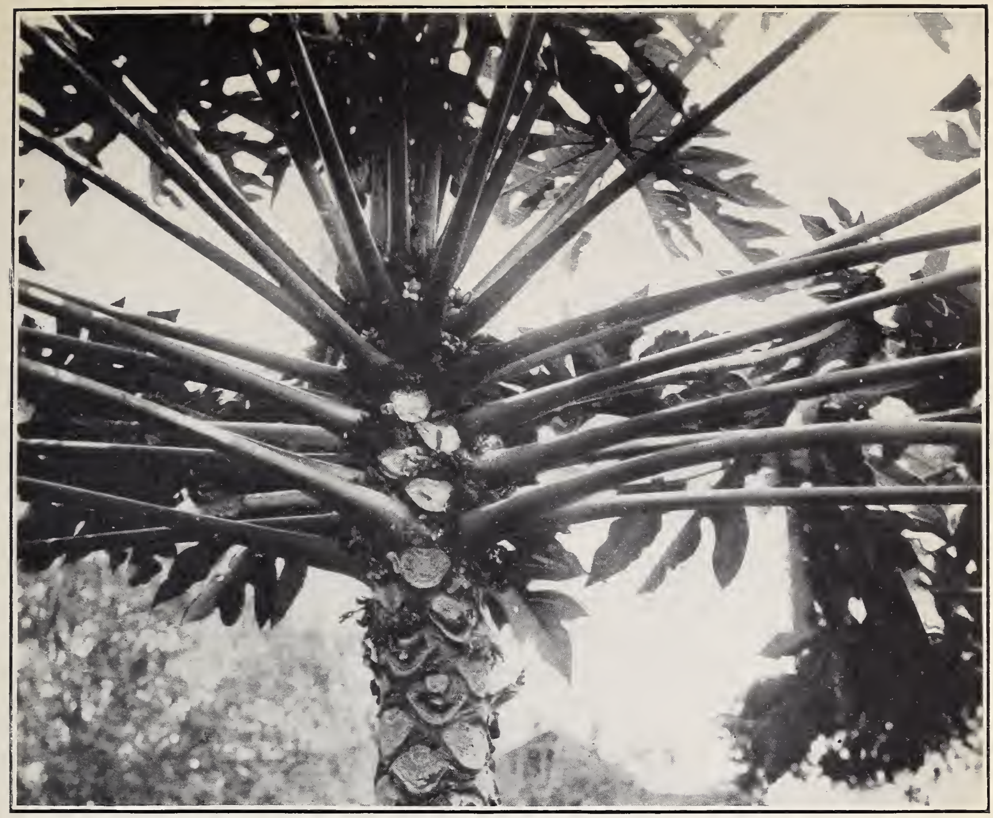

FIG. 1.—A STAMINATE PAPAYA TREE WITH VERY SHORT FLOWER STEMS.

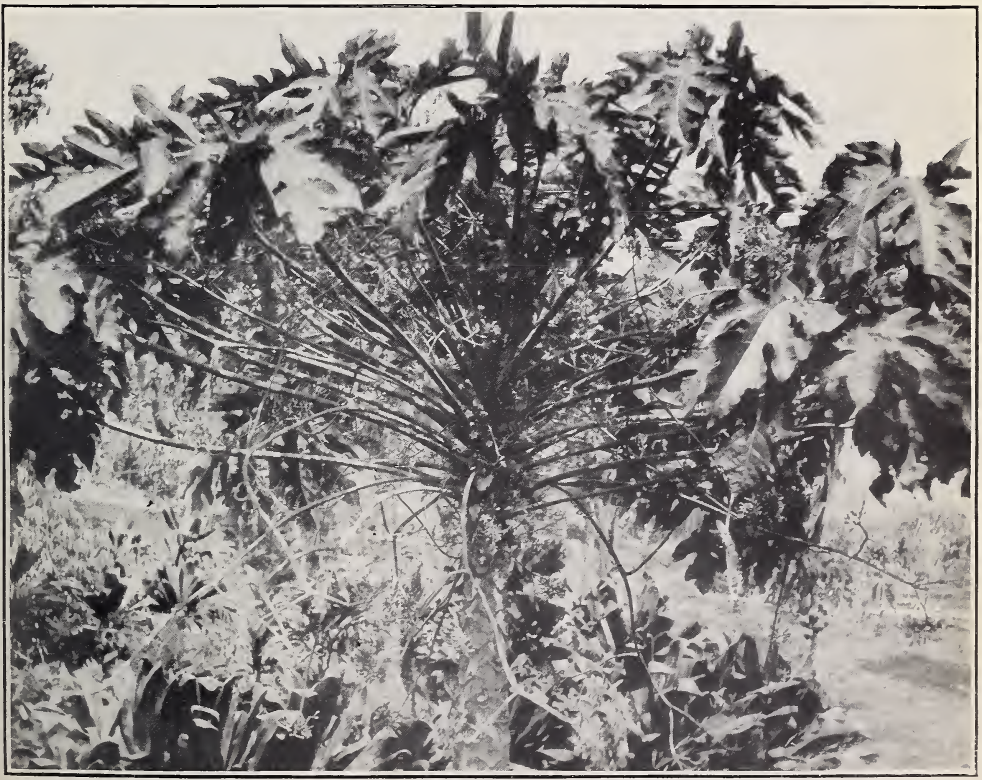

FIG. 2.—A STAMINATE PAPAYA TREE BEARING NO FRUITS.

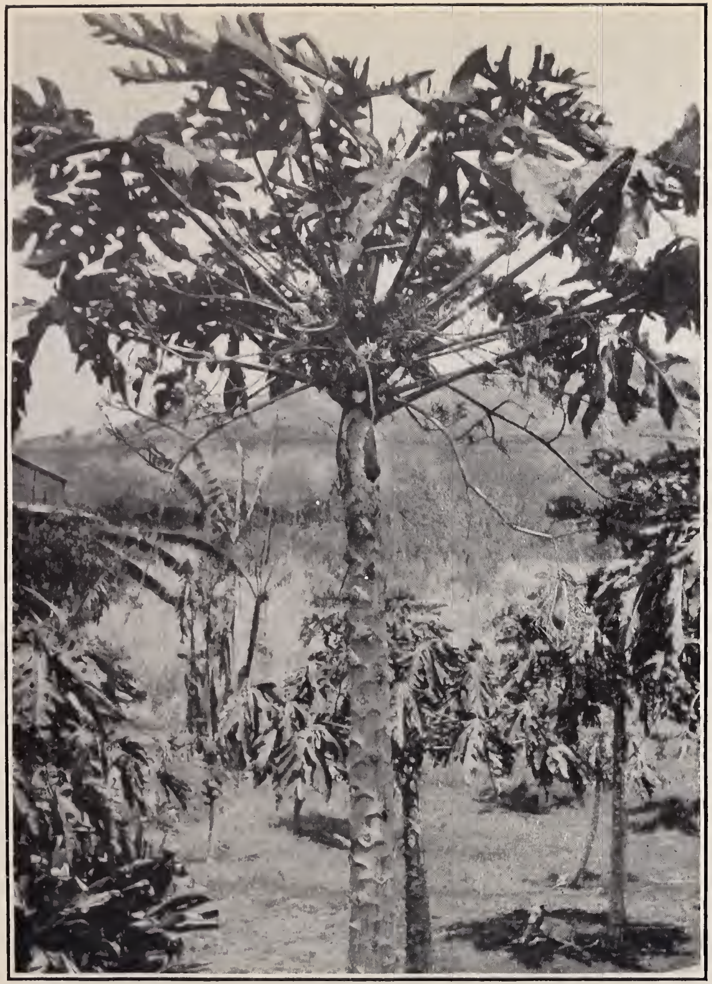

FIG. 1.—STAMINATE PAPAYA TREE BEARING ONLY TWO OR THREE FRUITS.

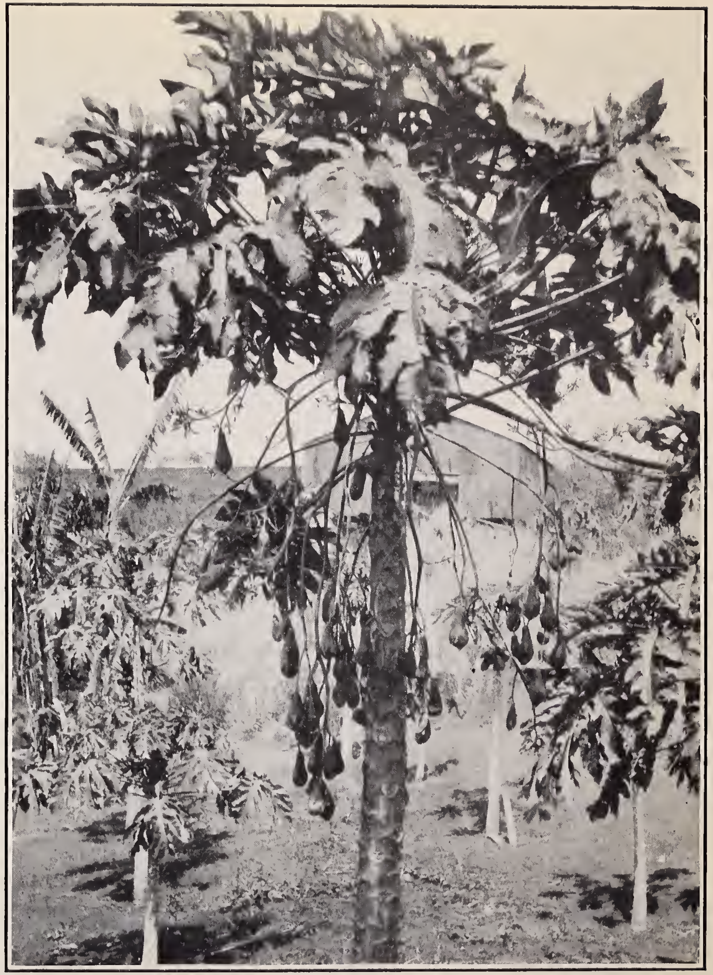

FIG. 2.—STAMINATE PAPAYA TREE BEARING MANY FRUITS.

gested and not the reverse—viz, from monœcious to diœcious? Proceeding temporarily upon the supposition that the monœcious type was the earlier form, it may be imagined that the peduncles became lengthened and the number of staminate flowers increased and the perfect flowers decreased until the evolution had arrived at a regular nonfruit-bearing staminate tree. But this would not account for the pistillate tree, which is the necessary counterpart of the staminate. To account for this, supposing the evolution to have proceeded in the direction hypothecated, it would be necessary that a pistillate flower of entirely new form be evolved from the perfect flower. All of this appears less probable than the suggestion that the diœcious type was the more primitive and gave rise to the monœcious.

In this connection it may be well to record a recent experience in planting. Papaya seeds were received from the United States Department of Agriculture, Office of Seed and Plant Introduction,[1] and planted under our accession number 1996. Sixty seedlings were set out in orchard form. Of these, 33 proved to be pure pistillate trees and 27 were staminate, a few of the latter producing an occasional fruit. One of these fruits was selected and its seeds planted. Of these, 16 trees were planted, and 4 of these are normal pistillate and 12 are staminate. But of the staminate trees 9 are bearing fruit and some of them in large numbers, such as 21, 37, and 87 fruits per tree. This may have some bearing upon the question which has been under discussion. In any event, the facts are of sufficient interest to record.

The work of breeding toward a reasonably stable variety of desired characters by means of cross pollination, close pollination, and selection is being carried on, and some excellent trees are being studied.

BANANA SHIPPING.

The shipping of bananas from Hawaii to the mainland has undergone some changes during the year. The spreading of the Mediterranean fruit fly in different islands of the group has led to increasing vigilance and greater caution on the part of California. It was thought that the banana leaves, in which the fruit has always been wrapped, were not a very safe packing. It was therefore directed by the California authorities that banana leaves must not be used, but that rice straw would be an acceptable material for the purpose. After a few shipments it was learned that the rice straw injured the rind of the fruit, causing it to become black. Then followed the testing of a paper wrapping inside of the rice straw and also of a cheesecloth wrapping. Each of these is reported to have afforded considerable protection, and one or the other is now in general use. Scale insects and mealy bugs of several species have also made it necessary to guard carefully incoming bananas at San Francisco. Because of these various difficulties some experiments were made in fumigating bananas with hydrocyanic-acid gas. Six bunches of bananas were secured on March 23 and held in the fruit room until March 29. Two bunches were then treated with 1½ ounces cyanid in 260 cubic feet for 45 minutes. Two others were given 2 ounces of cyanid for 45 minutes, and the remaining two were held as a check without treatment. The wrapping had been removed from all before treatment. Repeated examination of all these daily until ripe revealed no indication of any injury to the fumigated fruits.

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[1] S. P. I. No. 23915.

Again on April 3 a plantation was visited and six bunches were selected which were infested with the following scale insects and mealy bugs: Florida red scale (*Chrysomphalus aonidum*), the whitewash scale (*Hemichionaspis minor*), and a mealy bug (*Pseudococcus* sp.). These bunches were wrapped at once in banana leaves and taken to the experiment station, where they were held for two days. They were labeled 7, 8, 9, 10, 11, and 12, and treated on April 5 as indicated below:

No. 7. Not wrapped, not fumigated (check).

No. 8. Wrapped, not fumigated (check).

No. 9. Not wrapped, 1½ ounces cyanid in 260 cubic feet for 45 minutes.

No. 10. Wrapped, 1½ ounces cyanid in 260 cubic feet for 45 minutes.

No. 11. Not wrapped, 2½ ounces cyanid in 260 cubic feet for 60 minutes.

No. 12. Wrapped, 2½ ounces cyanid in 260 cubic feet for 60 minutes.

The fruits were carefully examined by the station entomologist after treatment, but in no case was a living insect found upon the fumigated bunches whether bare or within the wrapping. All were kept until fully ripe, which in the case of some bunches was over three weeks, and during this time careful observations were made by several members of the staff to discover any injury that might have been done to the fruit in fumigating. No difference could be detected between the fumigated and unfumigated fruit in appearance, texture, or flavor. It has been reported that injury has resulted from the treatment of bananas with this gas in San Francisco. It seems not improbable that this may have been the case, for bananas coming from a ship after a six-day voyage are liable to be moist, and it is a well-known fact that hydrocyanic-acid gas is injurious to tender plant tissues when they are wet. But from the experiments recorded above it is reasonable to conclude that if fumigation is necessary it may be practiced here before shipping without injury to the fruit and with deadly effect upon the insects.

HIBISCUS.

The hibiscus is now receiving much public interest and more requests have been received for cuttings of these plants than for any other. Over 25,000 cuttings have been distributed. Mr. Holt, who has charge of the hibiscus work, states that he now has over 200 new varieties under observation. Some of these are of great beauty and will add much to the floral wealth not only of Hawaii but of other parts of the Tropics and Subtropics. One of the most attractive of the new sorts is shown in Plate II, fig. 1. Mr. Holt has named this the Ruth Wilcox. A half tone can not do justice to such a flower, but reveals the free-flowering habit and good form of shrub. This is one of the few hibiscuses which emit a delicate perfume.

CITRUS.

The orchards of citrus which have been budded to many varieties are now coming into bearing. In the report of the assistant horticulturist will be found a list of the varieties which are fruiting.[1]

Bud wood of a number of these varieties has been distributed to various parts of the Territory and about 320 stocks in the station nurseries have been budded to some of the most promising.

The records of two trees budded to Kusaie lime in May, 1908, are worthy of note. They began fruiting in the fall of 1909 and have been in bearing almost constantly since that time. A record was kept of the yields in 1911, showing 467 fruits weighing 40½ pounds from one of these trees and from the other 419 fruits weighing 39½ pounds.

MISCELLANEOUS EXPERIMENTS AND OBSERVATIONS.

The horticulturist made a short trip to the island of Kauai in September to render some assistance to the Homestead substation and arrange for some trials in onion growing. Seeds of a large number of varieties of onions including some of the Bermuda type were later sent to Kauai and were planted at the substation at Homestead and in several other parts of the island.

At that time it had been rumored that the Mediterranean fruit fly had appeared at Makaweli. A brief investigation proved this to be the case and on August 28, immediately after the adult insects had been bred from the material collected on Kauai, the information was communicated to the Commissioner of Agriculture and Forestry. In May another visit was made to Kauai to review the onion tests mentioned above, to give some instructions in propagation at the substation, and to study the pineapple industry on that island. The last two subjects have been noted earlier in this report or in a press bulletin of the station on The Pineapple in Hawaii[1] and need not be further reported upon here. Some mention should be made of the results of the onion tests. The marketing division of the Territorial government had also distributed some very good seeds of the Bermuda type. Onions were found growing in many places from Waimea to Hanalei and in soils varying from heavy clay to light coral sand mixed with a small amount of humus. In general it may be stated that first-class marketable onions were found in many soils and at elevations ranging from sea level to 600 or 700 feet, which appeared to be about as high as they had been tried. On all the heavier soils, however, a serious disease was prevalent which appeared to be identical with the bacterial disease of this crop known as "center rot" or "slippery onions."[2] This disease may attack the top of the bulb and progress into the center, giving rise to the first of the names applied to it, or it may affect the outer scales causing them to decay and the onion to be very slippery, which has given rise to the second of the common names. The malady is one which prevails chiefly in heavy soils and in damp climates. Very little of it was found on the low sandy soils of Kauai, lying near the beach and supplied with moisture chiefly from beneath. In several places it was found that free water exists only a few feet below the surface of the soil and is conducted to the plants by capillarity. There is a considerable area of sandy and loamy soil on Kauai which appears to be adaptable to this crop, but as there is no effective remedy for the bacterial disease referred to, cultivation on the heavier soils should not be attempted without caution.

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[1] See page 48.

In closing it is desired to express appreciation of the very faithful services of Mr. C. J. Hunn, assistant horticulturist, and of Mr. Valentine S. Holt, assistant in horticulture.

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[1] Hawaii Sta. Press Bul. 36.

[2] New York State Sta. Bul. 164; Georgia Sta. Rpt. 1900, p. 355.

PLATE V.

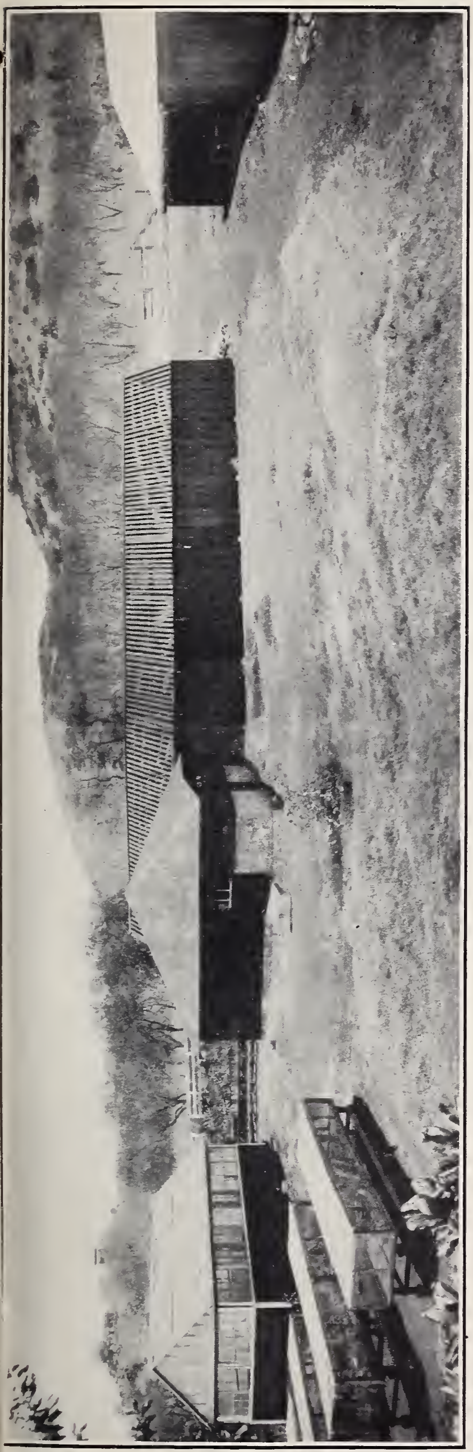

FIG. 1.—PANORAMA OF BUILDINGS.

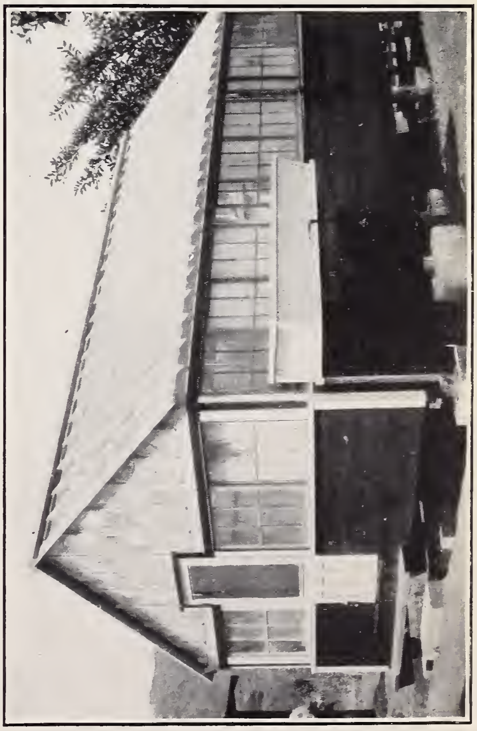

FIG. 2.—GLASS HOUSE.

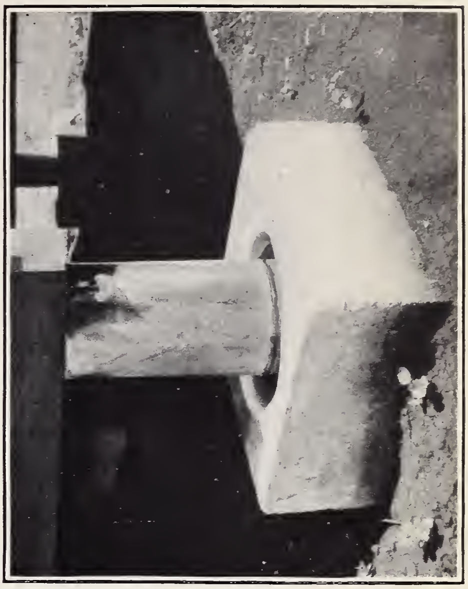

FIG. 3.—CEMENT PIER.

GENERAL VIEW OF HORTICULTURAL BUILDINGS.

REPORT OF THE ASSISTANT HORTICULTURIST.

By Chester J. Hunn.

BUILDINGS.

The year has been essentially one of reconstruction and building up. While passing through the transitional period between the discarding of the old and the actual construction of the new buildings (Plate V) six outside ant-proof benches [1] were erected.

A shade house supported by concrete pillars was the first building constructed. The slats in the old shade house showed a tendency to warp in all directions and to throw into the house the water that should be drained away. The adaptability of two grooves, one on either side and three-quarters of an inch from the edge of the upper surface of the slat, is now being tested. The opinion is that when the slats warp they will turn upward and form a trough which will insure better drainage.

Adjoining the shade houses is a potting room. It has a rock floor covered with a sloping concrete surface. In this room are a spacious potting bench, reinforced concrete bins for soil and sand, pot racks, and a packing table.

The necessity of a glass house for propagating purposes has been very apparent. It should be proof against insects, birds, and rodents, for the former shade houses were faulty in this respect. The regulation of temperature and air currents has also not been within the control of the propagator.

A glass house which should fulfill these conditions is practically finished, detailed plans of which are given herewith (fig. 1). All the supports and the piping are ant proof. Wooden doors near the floor, sliding glass sash on the sides, and ventilators in the roof control the ventilation of the house. All openings are covered with bronze mosquito wire. The intensity of the sun's rays will be regulated by whitewashing the glass and by the use of curtains.

The interior arrangement of the house affords means for several methods of plant propagation. The center bench is zinc lined for subirrigation purposes, especially for delicate seeds which do not permit of surface watering. At one end is a glass box for seeds requiring a high temperature in which the amount of humidity can be controlled.

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[1] Hawaii Sta. Rpt. 1911, p. 42.

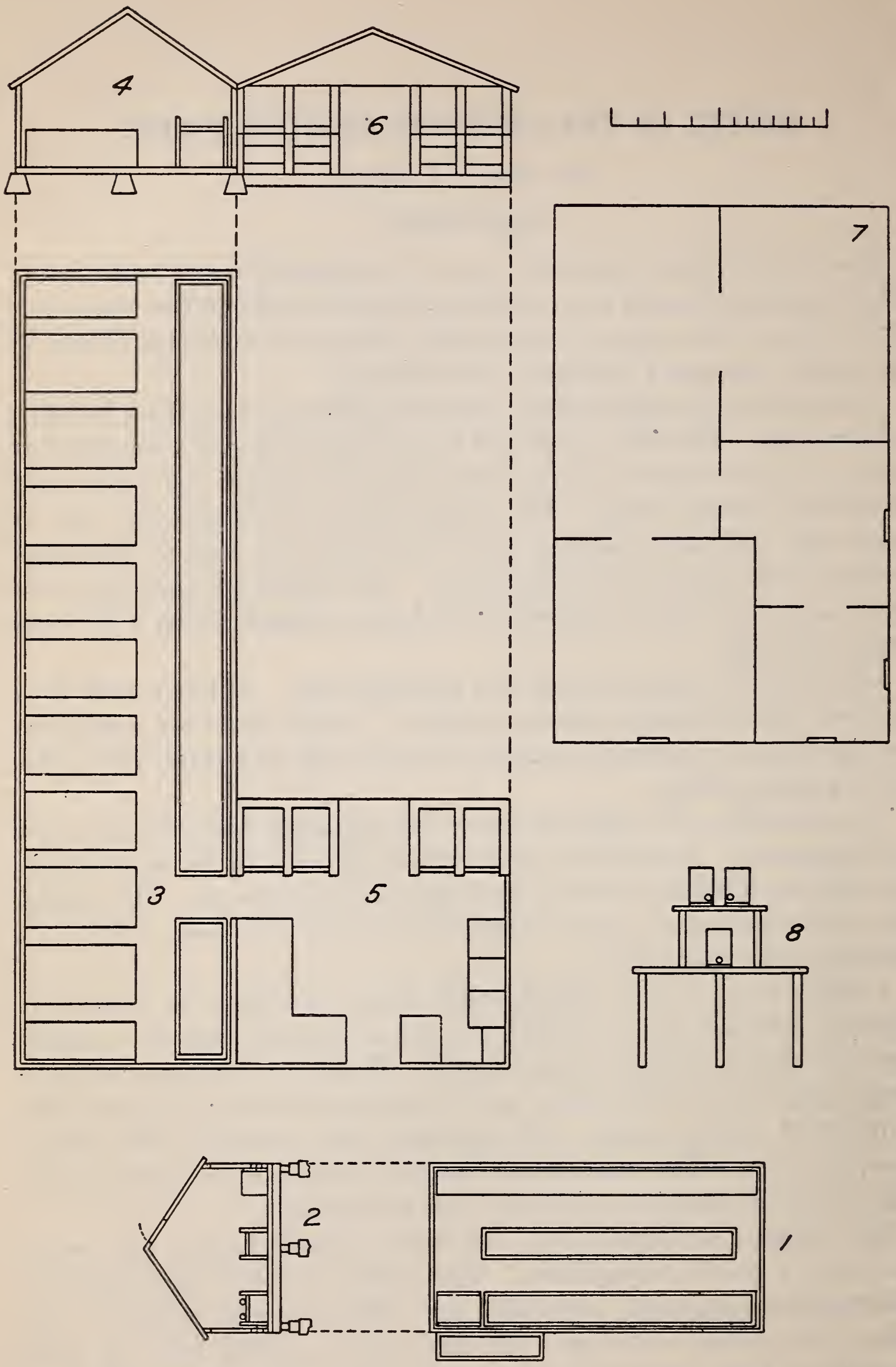

FIG. 1.—Details of horticultural buildings: 1 and 2, interior bench and elevation plans of glass house; 3 and 4, same of shade house; 5 and 6, same of potting house; 7, interior plan of work house; 8, elevation plan of spray stand. (Scale 16 feet to 1 inch.)

Experience in propagation by cuttings in the Tropics leads to the belief that bottom heat is necessary to the best success. Temperature readings in a thickness of 6 inches of moist sand show that the surface temperature is 6° higher than the bottom temperature. Cuttings should callus and root before the leaves reach a large size, in order to provide a portion of the sustenance for the leaves and to prevent them from using much of the material stored in the tissues of the cuttings. Under prevailing conditions the leaves uniformly appear before the root system has become well established.

Facilities are now at hand for practical work in the bottom-heating problem. Water, heated by the sun's rays in a glass-covered wooden box, is conveyed by pipe through the sand propagating bed. After the heat is dissipated the water is returned to the heater to complete the circulation.

This department has outgrown other appointments. This is being remedied by the construction of a work building divided into a poison room, rat and insect proof seed and fruit rooms, a storage room, and an open work compartment. A modern spray stand has been erected so that all liquids can be conveyed by gravity from the stock solution barrels to the mixing barrel and from hence to the spray barrel on a wagon. A reinforced concrete stove was also constructed. This stove affords a place for the cooking of spray mixtures, the boiling of fruit infested with fruit-fly eggs, and the melting of such material as wax for bandages.

PLANTINGS.

During the past year, the budded orchards have been increased by the successful transplanting of budded citrus and mango trees. Miscellaneous fruit and ornamental trees have been planted in their respective plats. The nurseries have been extended by plantings of citrus, mango, and avocado seedlings.

Cover crops as usual have been drilled into the orchards to hold the soil during the rainy season and to increase the humus content of the soil. The several varieties of cowpeas, pigeon peas, and jack beans that have been received during the year, as well as those varieties which have been segregated from seed collection, have been planted in plats for the production of seed.

SPRAYING.

Since the orchard trees are rapidly assuming mature proportions, it has become apparent that spraying operations could not be performed with the small, barrel spraying outfit. A double-acting cylinder spray pump that can maintain a pressure of 120 pounds or more per square inch has been secured. The outfit is complete with a 50-gallon barrel that has been fitted up with a mechanical agitator.

The avocado and mango orchards were sprayed once last fall.[1] These orchards have been sprayed once this season. The comparative freedom of the orchards from fungus disease shows that spraying is necessary and effective. The combined action of spraying and of the natural enemies has thus far kept the injurious insects well in control.

MAPPING.

One of the important lines of work undertaken this year was the revision of the field maps made in 1909. Some trees had died and many new ones had been placed in the orchards, making this revision imperative. Maps of these fields, by sections, have been bound by series in portfolios so that they are adapted to both field and office work. Every orchard tree has been labeled with a large painted tree label. After writing the number and name, the label was dipped in a thin solution of shellac, which insures its durability for some years.

A résumé of the maps shows that, excluding the Tantalus plantings, the hibiscus, and the windbreaks, we have the following trees:

Small citrus seedlings	1,436	Small avocado seedlings	308
Large citrus seedlings	191	Large seedling avocados	181
Budded citrus	184	Large budded avocados	15
Small mango seedlings	705	Large inarched avocados	7
Large mango seedlings	263	Small inarched avocados	5
Large budded mangoes	25	Figs	70
Large inarched mangoes	35	Papaya	490
Small inarched mangoes	20	Miscellaneous fruits	425
Ornamental trees	597	Ornamental shrubs	596

The budding work on the citrus seedlings has proceeded as in former years. This budding has not only required skill in placing the buds, but has demanded much attention in irrigation and in protection against ants, aphis, and scale insects.

The following varieties of budded citrus are now bearing fruit:

Oranges: Dancy, Golden Buckeye Navel, Mediterranean Sweet, Navelencia, Paper Rind, St. Michael, Ruby Blood, Satsuma, Thompson Improved Navel, Valencia Late, and Washington Navel.

Pomelos: Duncan, Marsh Seedless (California), Marsh Seedless (Florida), and Triumph.

Lemons: Eureka and Villa Franca.

Limes: Kusaie, Seedless, and Tahiti.

Miscellaneous: King Mandarin, Willow-leafed Mandarin, and citron of commerce.

THRASHING.

The amount of labor necessary to thrash and clean the seeds of legumes to be used for cover crops has become so great that a small power thrasher was secured. This machine can be successfully used for pigeon peas and cowpeas. Although it will thrash the jack bean, the beans have to be separated by hand from the refuse.

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[1] Hawaii Sta. Bul. 25, p. 24.

ACCESSIONS.

This department is continually receiving seeds and plants from various parts of the world. These are planted and, if subsequent testing proves their worth, the increase is distributed. Others of known value are immediately distributed. Among the accessions of the past year are a collection of passiflora plants and papaya seed from the Office of Seed and Plant Introduction; seeds of papaya varieties from the West Indian Islands, Central America, and Bolivia; varieties of roselle from Africa; onion seed from Madeira; and several varieties of cowpeas. The plantings of fiber Musas other than those of the true commercial Manila hemp have been made. Seedling plants of the Philippine variety, Maguindanao, grown at Washington, have been received. The plants which have been grown as *Carissa arduina* have been identified as *C. grandiflora.* Seeds of the true *C. arduina* are now germinating. The varietal collection of avocados has been increased by California, Kona, and Honolulu varieties, the latter being principally of described varieties.

DISTRIBUTIONS.

During the past year this department has filled requests for plants and seeds for many agricultural institutions. The public in general has requested material assistance, which has been granted whenever possible.

Several years ago this department secured seeds of an improved type of the so-called "Easter or Bermuda Lily," a cross between *Lilium longiflorum giganteum* and *L. multiflorum.* The transmission of fungus diseases is prevented by the use of seed. When the bulbs and plants were taken up this year several new plats were started. There is now a large number of plants from "scale" propagation on hand for distribution.

RECORDS.

From the time that accession records have been kept, these records show over 3,000 entries of seeds and plants. Seeds have failed to germinate, plants have not survived the struggle for existence, and others have served their usefulness. With the revision of the field maps came the task of bringing these records up to date. Instead of five chronologically arranged accession books there are now two, which include only live material. The corresponding index cards have been filed. The discarded index cards and the distribution cards have each been filed away for future reference.

MISCELLANEOUS.

At the poultry show practical examples of grafting and budding in all stages of manipulation and growth were shown. The fruits of budded citrus trees, together with the novelties that were in season, were displayed. The results of selection with the papaya were noteworthy. The demonstration of the various stages of practical plant breeding with the hibiscus promises to increase the number of amateur breeders. The exhibit of hibiscus flowers, averaging 200 or more daily, was a signal effort on the part of Mr. Holt.

The avocado trees in the Hilo district appear to be suffering, and a few recovering, from some fungus disease. The results of this attack, unusual rainfall during the blossoming period, the abnormal abundance of lichens, and the lack of judicial pruning have made the fruit scarce and lacking in quality. In the forest area of the "aa" flows which lie between Hilo and Puna are scattered avocado trees just coming into bearing. These trees have grown up from seed scattered by trainmen.

In Puna the avocado trees appear moderately vigorous, although they are planted in a somewhat dry soil. The fruits are reported to be watery, slightly fibrous, and to lack the usual agreeable flavor.

In Kona the avocado is not planted in orchard form, but is grown in dooryards and in and about the borders of coffee plantations where the pockets of soil are of a sufficient size. Kona produces much of the off-season fruit marketed in Honolulu. A few fruits were still in season. The trees with few exceptions are neglected.

REPORT OF THE ASSISTANT CHEMIST.

By William McGeorge.

The chief lines of work which have occupied the attention of the chemical department during the year are as follows: A continuation of investigations upon soil conditions and an accumulation of a large number of analyses of soils with the idea in view of publishing a general survey of Hawaiian soils. Several miscellaneous investigations and analyses have been made, also a chemical study of the sisal leaf and the waste accruing from decortication, and some further studies upon the rice plant, dealing in the main part with the sulphur and chlorin content.

SOILS.

About 150 samples of soil have been examined during the year, a large portion of which were taken in proposed new pineapple land on this island and the Haiku district of Maui. The prime factor in the examination of soils to be used in growing pineapples has been the determination of the manganese content, the deleterious effect of which has been thoroughly dealt with in previous publications of this station. At this point it may be of some interest to state that the highest manganese content of any soil examined from the islands, other than Oahu, has been a sample from Lanai which contained 1.13 per cent. However, comparatively few soils from the other islands have been examined and a more thorough survey during the coming year is contemplated. In the course of this soil work some further attention has been given to the sporadic type of soil mentioned in the last annual report, namely, that of abnormally high titanium content, and some rather important results have been obtained. Samples of this type have been collected from several districts upon this island (Oahu) and one district at Haiku, Maui, which contains 18.84 per cent TiO_2 in the soil and 20.02 per cent in the subsoil at a depth of 30 inches. The soil of highest content contained 34 per cent TiO_2. It is possible that the precipitate of TiO_2 contained other of the rarer metals in small quantities. However, it was free from iron and aluminum. It was not deemed worth while at this time to attempt a separation of the rarer metals, but it may possibly be done later. These soils are of a vastly different type, both chemically and physically, from any of the other soils found in Hawaii heretofore. The normal Hawaiian soils contain about 5 per cent TiO_2. Apparently the titanium is the most insoluble constituent of the Hawaiian soils. These titanium soils contain a strikingly smaller content of aluminum and a higher content of ferrous iron, which probably imparts to them the characteristic blue or gray color.

LYSIMETER EXPERIMENTS.

The application of lime to the soils of the Wahiawa district on this island has failed to produce any visible improvement in their tilth. However, this is not surprising, in view of the fact that the Hawaiian clays are of a very different character from those of other countries. In view of the above fact a set of lysimeter experiments was started to observe the effect, both chemical and physical, of lime. The chief reason for the application of lime as fertilizer is to correct soil acidity and to supply a basic element to combine with the organic acids formed in the decomposition of organic matter, thus maintaining the neutrality of the soil. Also it acts indirectly as a source of plant food, by rendering available small quantities of mineral matter, particularly phosphoric acid and potash. Mechanically it has the property of causing a flocculation of clay, so that when the soil becomes wet and is subsequently dried the lime acts as a cement, holding the particles of clay together in larger aggregates.

The four soils selected for use in these experiments were of very different types. No. 1 was a heavy clay soil from the Wahiawa district, No. 2 a soil of "intermediate" manganese content, No. 3 a heavy clay soil in badly puddled condition, and No. 4 a highly manganiferous soil. Twelve lysimeters were used, three for each type of soil, one of which was used as a check. To the second carbonate of lime was added and to the third sulphate of lime. Twenty-five pounds of air-dried soil were used in each lysimeter, and the lime added in such quantity as to make an addition of 0.1 per cent of CaO. In each instance the lime was thoroughly mixed with the soil and a small quantity of water added, to dampen the whole before placing in the lysimeter. The following chemical and mechanical analyses show the types of soil used:

Chemical analyses of soils.[1]

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Titanic oxid (TiO_2)	2.25	0.03	0.50	0.68
Insoluble matter	39.26	40.66	38.22	31.67
Ferric oxid (Fe_2O_3)	24.33	14.99	27.89	18.60
Alumina (Al_2O_3)	14.65	19.71	13.86	14.67
Manganese oxid (Mn_3O_4)	.21	2.40	.10	9.21
Lime (CaO)	.50	.10	.05	1.32
Magnesia (MgO)	.36	.47	.80	.52
Potash (K_2O)	.49	.45	.34	.79
Soda (Na_2O)	.20	.22	.32	.38
Phosphoric acid (P_2O_5)	.06	.24	.14	.20
Sulphur trioxid (SO_3)	.08	.23	.17	.15
Volatile matter	13.65	15.75	12.17	16.78
Moisture	3.98	5.15	5.66	5.36
Total nitrogen	.32	.30	.31	.37

[1] Analyses made according to official method.

Mechanical analyses of soils.[1]

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Soluble in dilute HCl	2.07	....	....	2.71
Moisture	3.51	5.15	5.66	5.46
Organic and volatile matter	12.68	15.75	12.17	15.86
Fine gravel	.00	.04	....	.82
Coarse sand	.75	1.53	.45	7.74
Fine sand	3.51	8.49	3.47	21.22
Silt	8.54	8.60	5.67	13.18
Fine silt	33.33	29.75	42.85	21.87
Clay	35.01	30.57	29.94	12.40

[1] Analyses made according to Hall, The Soil. London, 1908, 2. ed., p. 51.

The experiments were started on April 13, 1911, and water was added from time to time to replace that lost by evaporation. After eight months samples were taken from each of the lysimeters for analysis, to determine the water soluble and 1 per cent citric acid soluble constituents, this being deemed a better means of working on the soils than by treating the soil with water in the lysimeters and collecting the percolations for analysis. In the analysis 100 grams of soil were placed in a glass bottle and extracted with 1 liter of water, at room temperature, with occasional agitation, for one week. For citric acid soluble matter 100 grams were extracted, with 1 per cent citric acid solution for the same length of time. The results of the analyses are as follows:

Water soluble constituents in parts per million.

Soil No.	Lime added.	Lysimeter No.	Al_2O_3 Fe_2O_3.	Mn_3O_4.	CaO.	MgO.	Na_2O.	K_2O.	SO_3.	P_2O_5.
....	Check	1	18	7	53	16	39	49	39	13
1	$CaCO_3$	2	11	6	91	12	54	89	47	5
1	$CaSO_4$	3	17	22	531	28	51	62	248	8
2	Check	4	11	9	53	14	40	55	30	40
2	$CaCO_3$	5	12	7	143	11	59	56	52	14
2	$CaSO_4$	6	9	37	554	48	47	91	270	16
3	Check	7	21	7	74	16	65	69	27	30
3	$CaCO_3$	8	5	9	151	18	60	74	46	38
3	$CaSO_4$	9	5	36	464	39	33	66	268	15
4	Check	10	9	7	249	40	79	133	65	57
4	$CaCO_3$	11	9	10	383	47	77	108	83	55
4	$CaSO_4$	12	3	13	907	69	127	133	407	47

This table does not show any very striking chemical effects resulting from the use of the lime, but at the same time some of the effects are of interest. The usual chemical changes resulting from the addition of lime, namely, an increase in the solubility of the phosphoric acid and potash, were not effected, which, however, may be due to experimental discrepancies. In every instance except one the lime caused a decrease in water soluble phosphoric acid. In the majority of instances it effected an increase in solubility of potash. It is also interesting to note that in every instance the addition of sulphate of lime produced a marked increase in the solubility of the manganese and magnesium. The water soluble phosphoric acid was determined colorimetrically from a solution obtained by extracting 500 grams of the soil in 1 liter of distilled water.

Citric acid soluble constituents.

Lysimeter No.	Lime added.	Fe_2O_3.	Al_2O_3.	Mn_3O_4.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.
		Per ct.	*Per cent.*	*Per cent.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Check	0.136	0.410	0.003	0.030	0.058	0.034	0.034	0.0057	0.050
2	$CaCO_3$	.154	.440	.005	.075	.056	.026	.026	.0051	.054
3	$CaSO_4$	.147	.445	.007	.078	.060	.032	.032	.0077	.112
4	Check	.132	.839	1.484	.050	.088	.052	.052	.0077	.085
5	$CaCO_3$	.129	.839	1.456	.085	.090	.045	.045	.0038	.100
6	$CaSO_4$	.129	.812	1.507	.075	.110	.045	.045	.0025	.195
7	Check	.206	.434	.040	.040	.088	.094	.094	.0077	.064
8	$CaCO_3$	.192	.452	.026	.048	.072	.096	.096	.0051	.100
9	$CaSO_4$	.198	.481	.044	.062	.076	.077	.077	.0045	.140
10	Check	.055	.508	1.907	.110	.140	.130	.130	.0077	.090
11	$CaCO_3$	.055	.496	1.950	.157	.120	.145	.145	.0038	.065
12	$CaSO_4$	.065	.490	1.965	.147	.155	.151	.151	.0083	.185

Apparently, from this table, there is little regularity in the changes effected by lime as regards the citric acid soluble constituents. Phosphoric acid and potash were in some instances decreased, while in others there was an increase. The action of sulphate of lime was similar to that shown in the previous table; that is, it effected an increase in the solubility of the magnesium in every instance except one and an increase in the solubility of the manganese in every instance.

NITRATES AND AMMONIA.

It was also considered to be of sufficient importance to observe the changes in the nitrates and ammonia content at various intervals, produced by the lime, comparing the results with the check lysimeter. The results of these tests are given in the following table:

Variation in nitrates and ammonia in different lysimeters, parts per million.

Soil sample No.	Lysimeter No.	Lime added.	Nitrates.		Ammonia.	
			June 13, 2 months.	Nov. 13, 8 months.	June 13, 2 months.	Nov. 13, 8 months.
1	1	None	7.8	3.5	56.4	56.4
1	2	$CaCO_3$	7.3	6.9	33.6	28.2
1	3	$CaSO_4$	10.4	2.6	33.6	28.2
2	4	None	15.65	8.7	33.66	56.4
2	5	$CaCO_3$	17.85	1.3	39.6	28.2
2	6	$CaSO_4$	13.85	8.3	33.6	28.2
3	7	None	15.65	3.0	16.9	28.2
3	8	$CaCO_3$	25.00	4.4	16.9	42.3
3	9	$CaSO_4$	20.80	2.6	39.6	56.4
4	10	None	41.50	12.8	50.8	56.4
4	11	$CaCO_3$	17.85	10.5	39.6	56.4
4	12	$CaSO_4$	25.00	11.7	56.4	42.3

While the above tests do not duplicate field conditions, they indicate a great variation in nitrogen content and a striking decrease in nitrates upon standing in the lysimeter under normal climatic conditions. These tests also indicate the necessity of further work being carried on along this line before reaching any conclusion as to the effects of the different forms of lime upon the nitrate and ammonia content of these soils.

EFFECT OF LIME ON CAPILLARITY.

The only means the surface soil possesses by which it is able to replace the moisture lost on evaporation is capillarity. Of the several kinds of water existing in soils, the capillary form is probably the most important, for the above reason. It not only serves as a means of supplying moisture to the plant during dry weather, but also as a carrier for plant food. This capillary movement of moisture is caused by surface tension, and it is of some interest to know the effect of lime upon this property of the soil. Accordingly, a set of glass tubes, 2 centimeters in diameter, were fitted up and the rate of capillary rise and downward capillarity determined, with the following results:

Upward capillarity.

Soil sample No.	Time.								
	1 hour.	3 hours.	7 hours.	24 hours.	48 hours.	72 hours.	96 hours.	5 days.	6 days.
	Cm.	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*
1	14.0	19.5	25.0	32.75	....	41.25	43.5	45.75	47.5
2	14.5	20.5	26.75	35.5	....	43.75	46.0	48.0	49.5
3	12.75	18.5	24.0	30.25	....	36.5	38.0	40.0	41.25
4	19.5	24.5	30.0	37.5	42.5	46.0	48.25	50.5	53.5
5	18.5	23.75	29.25	37.0	42.0	44.5	46.5	48.25	50.5
6	16.0	21.5	28.0	36.25	39.75	41.5	42.75	44.0	45.5
7	9.75	14.5	18.25	24.0	....	30.5	31.75	33.0	34.25
8	9.75	13.25	17.5	23.25	....	28.5	30.25	31.5	32.25
9	10.5	13.5	17.25	23.25	....	27.75	29.5	30.75	32.0
10	20.0	26.5	34.5	46.0	52.0	56.0	59.5	61.75	65.25
11	19.0	26.5	33.25	42.5	46.5	49.0	51.0	52.75	55.0
12	19.5	26.5	33.25	43.0	49.25	53.0	56.0	58.0	61.0

In this table the capillary rise is shown to be more rapid where no lime had been added to the soil in every instance except that of soil No. 1, a heavy clay. The sulphate of lime decreases the rate of capillarity in every instance, and in all cases except the last the rate is less than that where carbonate had been used. In these experiments the glass tubes were allowed to stand in water, the end dipping about one-half inch into the water.

Downward capillarity.

Soil sample No.	Time required for disappearance of water below surface.	Penetration of water at time of disappearance from surface.	Final depth.
	Hr. min.	*Cm.*	*Cm.*
1	3 7	36.0	46.0
2	3 4	34.5	44.0
3	1 55	34.0	44.0
4	1 21	38.0	50.0
5	1 49	34.5	45.5
6	1 52	34.5	45.5
7	4 27	34.0	41.0
8	6 55	34.0	39.5
9	3 28	34.0	42.5
10	1 36	31.0	38.5
11	1 44	33.5	41.5
12	1 54	33.0	40.5

From this table it may be seen that the manganiferous soils, Nos. 2 and 4, are not greatly affected by the addition of lime beyond a slight decrease in the rate of downward movement of the water. The soil containing 2.4 per cent Mn_3O_4 (No. 2) showed a slight decrease in the depth to which the water reached, which indicates an increase in the absorptive power of the soil by use of lime. The highly manganiferous soil (9.2 per cent) showed the opposite effect, namely, an increase in depth to which the water reached and a decrease in absorptive power. A glance at soil No. 1 shows an increase in rate of downward movement of the water and also an increase in the absorptive power as a result of the addition of both forms of lime. But soil No. 3, which contains about 6 per cent less clay, shows a much more striking variation in rate of capillarity, but very little difference in the final depth to which the water reached. The rate of capillarity is strikingly less than that of any of the other soils and is an excellent example showing the effect of plowing these soils when they are too wet. The soil had become more colloidal than normally, due to puddling, and on drying assumed the form of very hard lumps which, on wetting again, were difficultly permeable to water. In these experiments 45 cubic centimeters of water was poured into the top of the glass tube.

FERTILIZER EXPERIMENTS WITH TARO.

In August, 1910, the station began some fertilizer tests on taro to determine the relative economic value of the use of fertilizers in various proportions and mixtures. These experiments were made in conjunction with the Kalihi Poi Factory and upon their taro plats. These experiments have been completed, and the data accumulated therefrom present some results of considerable practical value to taro growers, and in addition are of some scientific value.

The field was divided up into seven plats, each approximately one-twentieth of an acre in area. The fertilizer was applied on August 5 and the taro planted on August 15. To plat No. 1 superphosphate and sulphate of potash were added; to No. 2, nitrate of soda, superphosphate, and sulphate of potash; to No. 3 no fertilizer was added; No. 4, ammonium sulphate, superphosphate, and sulphate of potash; and No. 5 received ammonium sulphate only. The same fertilizer was applied to plats 6 and 7 as to No. 4 except that in the case of No. 6 it was applied on September 16, just before planting, while on No. 7 it was applied two months after planting in order to determine if the time of application would cause any great variation in results.

On August 29 the plants in plat No. 2 appeared to be about twice as large as the check plat, in plat 1 they were smaller, while in 4 and 5 they were about the same size as in the check plat. On September 12 the plants in plat 1 had assumed a yellowish color and were still smaller than those in the check plat. In plat 2 they were still larger than the check plat, but also were yellow. Plats 4 and 5 at this date showed great improvement, and the plants were larger than in any of the other plats and of better color, No. 5 appearing especially green. The final results of the experiments are shown in detail in the following table:

Effect of various fertilizers on taro.

No. of plat.	Fertilizer applied.	Amount per acre.	Yield of taro.	Yield of poi.	Percentage of poi in taro.
		Pounds.	*Pounds.*	*Pounds.*	
1	Superphosphate	450	1,499	1,050	70.0
	Sulphate of potash	450			
2	Nitrate of soda	400	1,751	1,010	57.6
	Superphosphate	450			
	Sulphate of potash	400			
3	No fertilizer		1,231	920	74.7
4	Ammonium sulphate	300	1,702	1,270	74.6
	Superphosphate	450			
	Sulphate of potash	400			
5	Ammonium sulphate	300	1,215	800	65.8

These experiments, while they were carried through only one season, indicate the economic value to be derived from the application of ammonium sulphate, superphosphate, and sulphate of potash to taro. In the second column are shown the weights in pounds per acre, the plats used being only one-twentieth of an acre in size; hence only one-twentieth of these weights were applied on each plat. The yields of taro and poi are given in pounds per plat and not in acreage figures. The weight of taro does not include leaves, but only the marketable root bulbs. Column 5 represents figures obtained in factory.

It is clearly evident from these results that the effect of nitrate of soda is to produce a bulb of greater weight and volume than any of the other fertilizers, but in so doing it causes a decrease in carbohydrate content, from which some doubt arises as to its economic value as a fertilizer, even though it produced 90 pounds more poi than the check plat. The mixture used in plat No. 4, namely, ammonium sulphate, superphosphate, and sulphate of potash, while it produced an increased yield of 350 pounds poi more than the check plat, does not produce an abnormal growth of the plant as in plat No. 2. This is shown by the fact that there is only 0.1 per cent difference in the percentage of poi in taro obtained from this plat and the check plat, which indicates the normal development of carbohydrates in the root bulb, which results are to be desired in all fertilizer applications.

The fact that taro is grown under soil conditions similar to those in which rice is grown suggests the possibility of these plants having the property of assimilating nitrogen in a somewhat similar form. It has been shown [1] that rice is unable to properly assimilate nitrogen when added in the form of nitrates, while on the other hand ammonium sulphate supplies the nitrogen in a form which produces a considerable increase in yields of both straw and grain. However, in the case of taro the nitrate produces a slightly larger root than the sulphate of ammonia, but less starch.

Plats 6 and 7 showed practically no difference in yield, indicating that no difference results from delaying the application of the fertilizer for two months. Also the yield of these plats was practically the same as that from plat No. 4.

SISAL.

During the year a brief study was made of the chemical composition of the sisal plant with a view to ascertaining some possible means of utilizing the enormous waste accruing from the decortication of the leaves. The results of this work have been published in a recent press bulletin.[2] The most attention was given to sisal and henequen, which are cultivated commercially in Hawaii. Investigations were made to determine their value as fertilizer, stock food, and as a possible source of industrial alcohol. Also a quite extensive chemical analysis of the leaves was made.

The most important finding brought out during the work was the identification of the normal acid of the leaf as lactic acid. So far as the author has been able to ascertain, the normal acidity of the leaf has never been determined. F. H. d'Hérelle [3] attributes the strong acidity of the leaf to oxalic acid, which he says is present in part. It is a very noticeable feature of the sisal fiber industry that the corroding of the machinery due to the strong acidity of the leaf is a factor to be considered, which has been overcome to a certain extent by the use of an especially prepared alloy. The Hawaiian Fiber Co. was desirous of knowing the identity of the acid and the possibility of its commercial value. The result was the discovery of lactic acid, as mentioned above.

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[1] Hawaii Sta. Bul. 24.

[2] Hawaii Sta. Press Bul. 35.

[3] Jour. Agr. Trop., 10 (1910), No. 108, pp. 161-167.

The result of the investigation indicates that obviously the best means of utilizing the waste is to return it to the soil as fertilizer. Although the manufacture of industrial alcohol is worthy of consideration, it is by no means promising, owing to the difficulties to be overcome in fermentation and the comparatively low carbohydrate content of the plant, which was found to be only 2 to 7 per cent of the fresh leaf.

EFFLORESCENCE ON LAVA BRICKS.

Among the miscellaneous investigations undertaken by the laboratory within the past year was one upon the occurrence of an efflorescence upon bricks made from ground lava rock. While it does not strictly represent an agricultural industry, still it was considered to be worth an investigation, being related in a way to the study being carried on in the laboratory upon lavas, their disintegration, etc.

The efflorescence was found to be composed of the carbonates or bicarbonates of sodium and potassium, which in some instances have been found to make their appearance in such large quantities as to give a wall made of these bricks the appearance of having been in the path of a snowstorm. So far as the author has been able to find out, these alkali carbonates have never been known previously to appear in this form, nor in such large quantities as an efflorescence.

The brick are made by pressing the ground rock after a slight addition of lime and dampening of the mixture. They are then dried under steam pressure. The conclusion reached was that the lime and the subsequent drying temperature cause the trouble. Sodium and potassium carbonates are not normal products of lava disintegration, although some of the vesicles in lava rock contain a coating of carbonate. Potassium and sodium occur in basaltic lava in the form of complex silicates. The lime at the temperature of the drying kiln probably replaces the sodium and potassium in these silicates and forms caustic soda and potash, which in turn are converted on contact with the air into carbonates and bicarbonates. This work has been presented to the Journal of Industrial and Engineering Chemistry for publication in more complete form.

SUNLIGHT.

The Philippine Bureau of Science for several years past has been engaged in an extensive investigation of tropical sunlight, paying especial attention to the actinic rays. At the request of this bureau the station has carried on a series of experiments extending over a period of one year to test the actinic power of the sun in Hawaii.

The theory has been prevalent that the sun's rays may be divided into classes of which the blue, violet, and ultra-violet rays are actinic, that is, capable of producing chemical reactions; also that these rays are a factor of great importance in relation to the effect of insolation on the white man in the Tropics. As a means of measuring this actinic power, Dr. R. F. Bacon, of the bureau of science, has utilized a solution of oxalic acid in the presence of uranium acetate. The latter compound acts as a catalyzer and eliminates the error which would ensue from side reactions, such as oxidation or formation of peroxid. The oxalic acid is decomposed by the actinic rays of the sun and the residual oxalic acid determined by titration.

DESCRIPTION OF THE EXPERIMENTS.

The following solution was exposed, in a Jena glass flask, to the direct rays of the sun, the flask being placed away from reflecting walls and on a sheet of dull black paper: Five cubic centimeters of a 1 per cent solution of uranium acetate, 5 cubic centimeters of a 10 per cent solution of oxalic acid, and 20 cubic centimeters of distilled water. This solution was exposed as above from 9 to 12 o'clock a. m. The solution was then titrated with N/10 potassium permanganate, after addition of 25 cubic centimeters of 1:5 sulphuric acid and heating to 60° C. From this titration the percentage of oxalic acid decomposed was determined. The permanganate solution was standardized quite often and all solutions kept stored in a dark place. Also the same flask was used throughout the year, as it was found that the results are affected slightly by using different flasks. It is hardly necessary to present the results in detail, but only the more important points will be brought out.

Maximum, minimum, and mean actinic power.

Month.	Maximum.	Minimum.	Mean.	Month.	Maximum.	Minimum.	Mean.
January	52.20	11.31	36.41	July	50.55	16.59	37.25
February	50.13	18.88	40.49	August	55.53	27.25	43.75
March	53.28	10.46	41.47	September	62.33	19.72	46.49
April	53.98	16.37	42.92	October	54.81	24.74	44.89
May	52.92	23.67	41.56	November	53.07	17.76	42.77
June	52.25	19.86	40.94	December	48.72	19.24	35.35

Column 1 shows the maximum decomposition obtained during the month, in column 2 the figures represent the minimum actinic power for that month, column 3 represents the mean monthly actinic power of the sun. That is, the daily percentage decompositions were added up for each month and the sum total divided by the number of days on which the actinic power was measured. The following curve (fig. 2) illustrates more plainly the variation of the actinic power of the sun throughout the year in Hawaii.

The above curve presents some very striking data, from which it may be readily seen that the actinic power of the sun is governed apparently by the position of the sun relative to the earth rather than such climatic factors as the rainy season or the hotter months of the year. The fact that the hotter months, namely, June and July, are so extremely low in actinic power further substantiates the finding of other investigators, namely, that the heat rays are not actinic, or at least only slightly so.

It is highly probable that the position of the sun at various stages of the earth's circuit around the sun is a factor to be taken into consideration. On March 21 and September 21 the sun is directly over the equator, and the curves for these months show the highest points for the first half and second half of the year. In like manner on June 21 and December 21, the months in which the sun reaches its longest distance above and below the equator, respectively, these points on the curve are the lowest and of least actinic power.

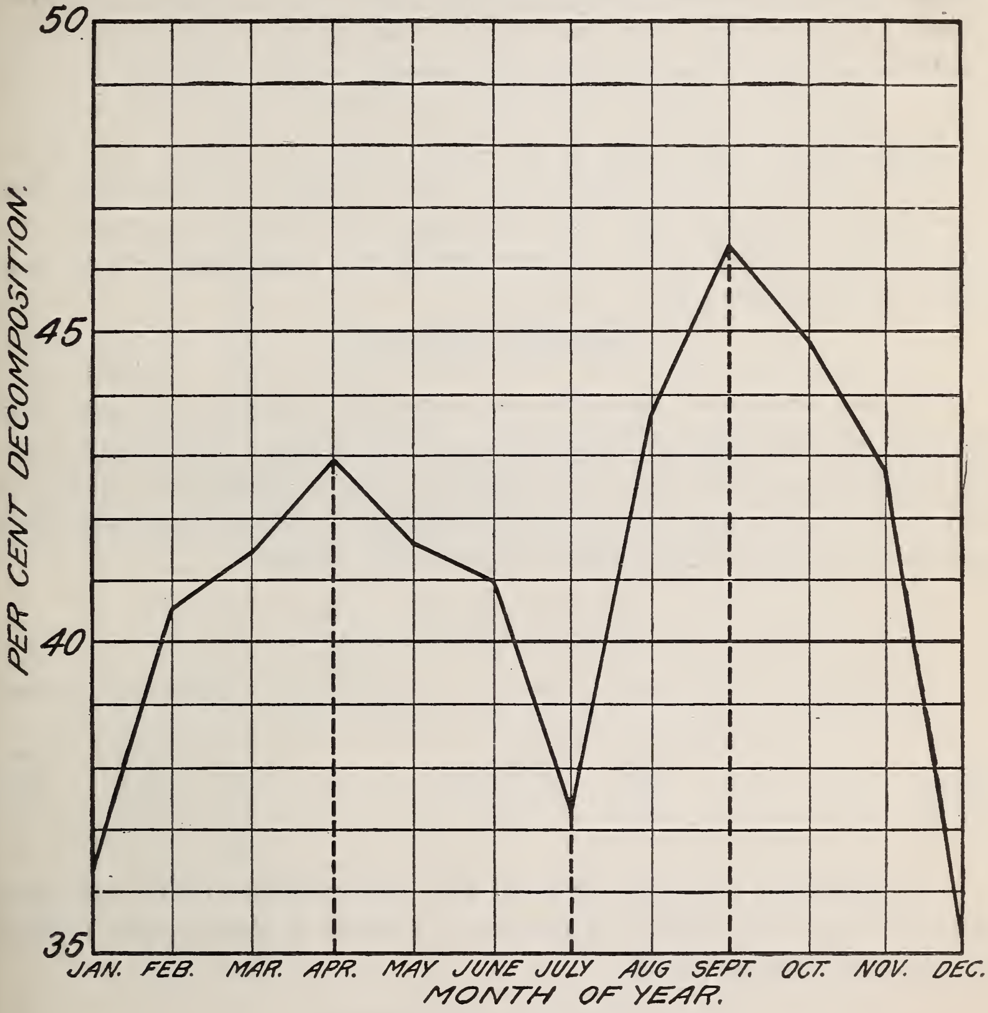

FIG. 2.—Actinic power of sunlight.

It has been found in the investigation that the lowest actinic days are those on which it is raining and cloudy. The mere fact that the day is cloudy, however, does not necessarily indicate a nonactinic day, as we have found cloudy days on which it is as strong as on many sunshiny days, indicating that the actinic rays to a great extent pass through the clouds. Sunshiny days vary considerably, some being actinic while others are much less so. Quite often hazy days were found to be very strongly actinic but like the sunshiny days, they were not regularly so. It was found to be a regular occurrence that a sunshiny day following a rain of the night before produced very strong actinic rays. For a short time tests were also run in the afternoon from 12 to 3 p. m., and it was found that the afternoon rays were more strongly actinic than the morning rays. That the points on the curve for the first half of the year are so much lower than those of the latter half is probably due to the fact that these months represent the rainy season, during which there were fewer sunshiny days, thus lowering the monthly average, even though the actinic days during this season were less actinic than those of the latter half.

MISCELLANEOUS.

A small amount of miscellaneous analytical work has been done during the year, among which were some analyses of Hawaiian rubber. The following table shows the maximum and minimum results obtained from the analyses of seven samples of crepe form, and represents the average composition of Hawaiian rubber:

Composition of Hawaiian rubber.

Constituents.	Minimum.	Maximum.	Constituents.	Minimum.	Maximum.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Protein	2.62	3.81	Ash	0.78	1.65
Resin	3.06	4.18	Gum	90.93	92.65
Moisture	.49	.89			

A comparison was also made of the composition of the crepe and biscuit forms of Hawaiian rubber and a sample of Malay crepe rubber, with the following results:

Comparison of crepe and biscuit rubber.

Constituents.	Malay crepe.	Hawaiian crepe.	Hawaiian biscuit.	Constituents.	Malay crepe.	Hawaiian crepe.	Hawaiian biscuit.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Proteids	3.50	3.25	5.37	Ash	0.37	1.13	1.40
Resin	2.67	3.55	3.08	Gum	92.84	91.40	88.86
Moisture	.62	.67	1.29				

Hawaiian rubber is shown to contain a higher percentage of ash and resins than the Malay rubber, the latter probably being due to a difference in the age of the trees as it is known that the resin content of some rubbers decreases as the age of the tree increases. The higher percentage of proteids in the biscuit form is due to the greater pressure under which the crepe rubber is washed.

Another analysis of some importance was that of the trunk of the fern tree (*Cibotium chamissoi*), which is being used to a certain extent as a hog feed, both raw and cooked, on the island of Hawaii. It occurs in immense quantities in districts of Hawaii and its utilization is a factor in the clearing of forests. An analysis has also been made of a sample of soy-bean cake.

Comparative analyses of fern tree trunks and soy-bean cake.

Constituents.	Fern.	Fern (dry basis).	Soy-bean cake.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	69.38	....	15.62
Ash	.33	....	24.52
Nitrogen	.18	....	2.76
Protein	1.12	3.65	17.25
Phosphoric acid	.10	.32	.08
Reducing sugar	3.99	13.03	....
Nonreducing sugar	.24	.78	....
Starch	20.92	68.32	....
Fat	....	....	18.76
Sodium chlorid	....	....	23.05
Nitrogen free extract and crude fiber	....	....	23.77

The high percentage of salt to be found in the soy-bean cake is due to the large quantities added during the fermentation which the mash undergoes in the process of soya sauce manufacture.

THE DETERMINATION OF SULPHUR AND CHLORIN IN THE RICE PLANT.

By Alice R. Thompson, *Assistant Chemist.*

In so complex an organism as one of the higher plants it is difficult even to suggest correctly the functions of the various elements found in it. Besides many other investigations, Loew[1] has defined the uses of phosphoric acid, sulphur, and chlorin in the plant.

Phosphoric acid is found in organic compounds such as lecithin, inosite, hexaphosphate, nuclein, and chlorophyll; also in inorganic form as calcium, magnesium, and potassium phosphate. Inorganic phosphate is found in small quantities in the foliage of plants, while the seeds contain almost no mineral phosphate, but usually large amounts of phosphorus in organic combination.[2]

Sulphur is also found in definite chemical organic compounds in the plant. Osborne,[3] who analyzed a large number of sulphur albuminoids in seeds, found sulphur in constant molecular amounts in the various purified substances he obtained. For instance, edestin contains 0.884 per cent SO_3, legumin, 0.385 per cent; gliadin of wheat, 1.027 per cent.

Sulphur also occurs as mustard oils in plants; mustard seed and onions are common examples of plants containing these oils.

Sulphur in mineral form as sulphates occurs usually in smaller quantities in plants. Arendt, Ulricht, E. Schulze, Berthelot and Andre, and Fraps[4] investigated the mineral form of sulphate in plants and found it to vary in different parts of the plant as well as in plants belonging to different families. Sulphates are also formed from the organic sulphur in germinating seeds.

Euler[5] believes that sulphur is held in reserve form in the plant as cystin, a dithio-diamido-dilactic acid—

$$\begin{array}{l} S-CH_2-CH\ (NH_2)\ COOH \\ S-CH_2-CH\ (NH_2)\ COOH \end{array}$$

which is an exceedingly energetic compound, from which hydrogen sulphid is split off in small but continuous amounts for the formation of albuminoids.

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[1] U. S. Dept. Agr., Div. Veg. Physiol. and Path. Bul. 18.

[2] New York State Sta. Tech. Bul. 1, p. 7.

[3] Connecticut State Sta. Rpt. 1900, pp. 442–471; Jour. Amer. Chem. Soc., 24 (1902), No. 2, pp. 140–167.

[4] North Carolina Sta. Rpt. 1903, p. 67.

[5] Grundlagen und Ergebnisse der Pflanzenchemie. Brunswick, 1909, pts. 2–3, p. 146.

Whether or not chlorin is a necessary ingredient of plants is quite unknown. Many investigators believe the presence of chlorin to be superfluous in plants. As chlorin is present in most soils as the very soluble salts of sodium, potassium, and magnesium, the plant absorbs it as it absorbs any soluble salt in the soil. Also, if chlorin be present in considerable amounts, it acts as a strong poison to the plant. Euler[1] points out that no organic compound containing chlorin in molecular combination has been isolated from any plant. Nobbe, Siegert, et al.,[2] in their experiments with buckwheat, showed that chlorin is required in this instance to carry the plant to maturity. Many believe that it is necessary for the translocation of carbohydrates, helping to render starch more soluble. Others (A. Mayer[3]) hold that even buckwheat can be brought to maturity without chlorin.

In this paper the author has sought to show the sulphur and chlorin content of the parts of the rice plant at three stages of growth, and to determine the effect, if any, of fertilizer on the sulphur and chlorin composition of the plant grown in natural soil conditions and in sand cultures; also to determine the amounts of sulphur and chlorin contained in the rice field soil and water. The phosphoric acid content of the plant has been given in a previous publication.[4]

From the obvious increase of sulphate ions in rice plants grown in silica sand and fertilized with ammonium sulphate, conclusions may be drawn that ammonium sulphate as such is absorbed by the plant. Free ammonia was found in the foliage of plants grown in the rice fields, and, as has been shown in a bulletin of the station,[5] the rice plant makes the best growth when nitrogen is supplied in the form of ammonia.

METHOD OF ANALYSIS.

The method followed in the analysis of the rice samples for total sulphur is that of Osborne,[6] slightly modified by Hart and Peterson[7] in that the water was not boiled off from the saturated sodium hydroxid solution and the melt from the sodium peroxid fusion of the rice sample was boiled out with water and not with acid. The author found that not enough emphasis has been placed on the influence of sulphur from the gas burners on sulphur determinations. In the first analyses made, the fusions were made over alcohol lamps, but the solutions were boiled in beakers covered with watch glasses over gas burners. The resulting blank determinations were high in sulphur, amounting to 0.03 per cent SO_3. All subsequent determinations were therefore made in a room shut off from gas fumes and both fusion and boiling made over alcohol lamps. The resulting blank determinations were practically nil in sulphur, as shown below:

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[1] Loc. cit.

[2] Landw. Vers. Stat., 4 (1862), pp. 318–340; 7 (1865), pp. 371–386; 13 (1871), pp. 330–400; cited by Euler, Grundlagen und Ergebnisse der Pflanzenchemie. Brunswick, 1909, pts. 2–3, p. 149.

[3] Jour. Landw., 49 (1901), No. 1, pp. 41-60.

[4] Hawaii Sta. Bul. 21.

[5] Hawaii Sta. Bul. 24.

[6] Loc. cit.

[7] Wisconsin Sta. Research Bul. 14, p. 2.

Blanks on sodium peroxid.

	Per cent SO_3.
Fused over alcohol lamp but solution boiled over gas flame	0.0009
Fused and solution boiled over alcohol lamps	.0001

Blank on reagents bromin and nitric acid negligible.

In acidifying the alkaline solution of the fused melt it was noticed that a very good indication of the neutral point was the continuous effervescence due to carbon dioxid or hydrogen peroxid gas that occurs just after the solution becomes acid.

Before this stage is reached the effervescence resulting from addition of acid does not continue when addition of acid ceases.

The precipitate of barium sulphate was treated with hydrofluoric acid and a few drops of sulphuric acid and ignited a second time to remove traces of silica that in a few cases contaminated the precipitate.

Duplicates on each sulphur determination were made and checked usually within 0.02 and 0.03 per cent.

The mineral sulphur was determined by stirring the sample with 100 cubic centimeters of cold 1 per cent hydrochloric-acid solution and allowing it to stand an hour before filtering. (In the case of the starchy grain the sample was boiled with the solution to render it soluble. No hydrolysis of sulphate occurred by this method, as no trace of sulphate was ever found in the grain.)

Chlorin was determined by the Volhard method (official method).[1]

The samples of rice plants for this work were collected March 23, April 19, and May 15, 1912, 10 clumps of the plants being selected from each of two plats at the trial grounds. The first series of plants was taken before the flowering and divided into foliage and roots for analysis. The second series was taken at the time of full-stage flowering and divided into panicles, leaves, stems, and roots. The third series was taken at maturity and divided into grain, chaff, leaves, stems, and roots. This plan follows that given in a previous publication of this station.[2]

The plats from which the rice was taken were the unfertilized and the complete ammonium sulphate fertilizer plats.

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[1] U. S. Dept. Agr., Bur. Chem. Bul. 107 (rev.), p. 23.

[2] Hawaii Sta. Bul. 21.

RESULTS OF ANALYSES.

The following table shows the sulphur and chlorin composition of the rice plant at the first harvest and compares the composition of plants grown in the two plats; one unfertilized, the other fertilized with ammonium sulphate, superphosphate, and potassium sulphate.

Sulphur and chlorin in rice at the first harvest.

(Water-free basis.)

	Check plat.			Complete fertilizer plat.		
	Foliage.	Roots.	Total plant.	Foliage.	Roots.	Total plant.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total SO_3	0.489	0.492	0.491	0.393	0.430	0.401
Mineral SO_3	.057	.208	.107	.079	.188	.102
Cl	.628	1.090	.780	.605	.949	.679

In this series the total sulphur percentage is higher than at any other period of growth. It is about equally distributed between the foliage and roots. In the samples from the check plat the total sulphur trioxid is about 0.1 per cent higher than it is in those from the complete fertilizer plat. This may be due to the fact that the plants in the complete fertilizer plat were much larger and had made more growth.

The percentage of mineral sulphur is highest in the roots, being almost four times as high in the roots as in the foliage; but it is much less than the total sulphur, showing the formation already made of organic sulphur in the plant. Chlorin is also highest at this first period and, like sulphur, is found in largest percentage in the roots.

Sulphur and chlorin in rice at the second harvest.

(Water-free basis.)

	Check plat.					Complete fertilizer plat.				
	Panicles.	Leaves.	Stems.	Roots.	Total.	Panicles.	Leaves.	Stems.	Roots.	Total.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total SO_3	0.245	0.395	0.169	0.305	0.2453	0.245	0.344	0.157	0.313	0.2294
Mineral SO_3	.000	.056	.009	.143	.0374	.000	.037	.036	.162	.0517
Cl	.200	.370	.349	.490	.3534	.174	.345	.352	.446	.3437

At the second period the difference in composition of the plants grown in the two different plats has become nil and no effect of fertilizers is shown in the percentage composition, although the plants were much larger and heavier in the complete fertilizer plat.

The percentage of sulphur in the total plant has decreased from the first period, the leaves having the highest content in sulphur, the stems lowest.

No mineral sulphur was found in the panicles, but this form was relatively high in the roots and leaves.

Chlorin had also decreased in percentage amount and was quite low in the panicles and high in the roots.

Sulphur and chlorin in rice at the third harvest.

(Water-free basis.)

	Check plat.						Complete fertilizer plat.					
	Chaff.	Grain.	Leaves.	Stems.	Roots.	Total plant.	Chaff.	Grain.	Leaves.	Stems.	Roots.	Total plant.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
SO_3	0.166	0.241	0.256	0.126	0.247	0.1933	0.118	0.231	0.195	0.120	0.292	0.1763
Mineral SO_3	.000	.000	.000	.000	.087	.005	.000	.000	.000	.000	.121	.008
Cl	.261	.040	.338	.605	.376	.306	.246	.038	.419	.522	.392	.314

At the third period the fertilizers show no effect on the composition of the plant.

Total sulphur is very small in the stems and chaff and about 0.23 per cent in the other parts of the plant.

Mineral sulphur is found only in the roots, showing that the plant has used up the mineral sulphur in the formation of organic material.

Chlorin is practically absent from the grain, though high in the stems.

Mature rice plants from plats under different fertilizer conditions were selected, 10 clumps from a plat, and analyzed separately to determine any influence of fertilizer on the sulphur, chlorin, or phosphoric acid composition on the straw and paddy of rice. In the following table the results show no difference in the sulphur or chlorin composition of these plants grown in the different plats. The ammonium sulphate plat shows a slight depression of the phosphoric acid absorbed by the rice plant.

Sulphur, phosphoric acid, and chlorin in rice plant.

[Water-free basis.]

Fertilizer.	No. of plat.	Straw.			No. of of plat.	Grain.		
		Total SO_3.	P_2O_5.	Cl.		Total SO_3.	P_2O_5.	Cl.
		Per ct.	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*
Check	24	0.204	0.278	0.445	34	0.255	0.926	0.058
Sulphate of potash, superphosphate	25	.193	.215	.449	35	.262	.954	.045
Ammonium sulphate, sulphate of potash	26	.189	.291	.461	36	.228	.861	.044
Ammonium sulphate, superphosphate	27	.207	.231	.511	37	.249	.879	.054
Check	28	.171	.245	.478	38	.247	.900	.051
Ammonium sulphate, superphosphate, sulphate of potash	29	.162	.255	.502	39	.254	.824	.056
Ammonium sulphate, superphosphate, sulphate of potash	30	.191	.242	.544	40	.235	.813	.050
Ammonium sulphate	31	.199	.240	.544	41	.250	.815	.046

The following table shows the amount of sulphur, chlorin, and phosphoric acid absorbed from the soil by the rice plant and indicates the possibility of sulphur fertilizations being required by a crop that absorbs about half as much sulphur as it does phosphoric acid for organic material.

That considerable amounts of sulphur are removed by various crops from the soil is shown by Hart and Peterson[1] who suggest the need of fertilization of soils by sulphur.

Boullanger[2] showed the favorable effect of sulphur on the bacterial condition of the soil. Demolon[3] obtained increased yields by the use of flowers of sulphur as fertilizer and believes it is transformed into sulphates in the soil. Bernhard[4] also secured larger crops by the use of sulphur fertilizer.

Amount per acre of sulphur, phosphoric acid, and chlorin absorbed by the rice plant.

	Check plat.	Complete fertilizer plat.		Check plat.	Complete fertilizer plat.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
SO_3	9.5	11.9	Calculated as S	3.8	4.8
Cl	14.9	21.1	Calculated as P	12.6	18.4
P_2O_5	28.8	42.0			

A partial analysis of the soil obtained at the rice trial grounds is shown in the table below:

Analysis of the soil obtained at the rice trial grounds.

	Per cent.
Total SO_3 (Osborne method)	0.123
Acid soluble SO_3 (official method)	.031
Water soluble (1 per cent HCl.)	.008
Acid insoluble residue SO_3 (Osborne method)	.022
Iron precipitate from official soil solution (Osborne)	.032
Steam distillation of soil, SO_3 determination	.001
Moisture	5.58
P_2O_5	.671
Cl	.016

In the Osborne method of determination, the melt solution was filtered in an alkaline condition so that the iron and titanium were separated from the solution in which the sulphate was precipitated. No ammonium salts were thus introduced, and ferric chlorid was eliminated.[5] In the official method, however, the iron was precipitated by ammonia in the cold, according to Treadwell,[1] so that no basic iron sulphate would tend to form.

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[1] Wisconsin Sta. Research Bul. 14, p. 5.

[2] Compt. Rend. Acad. Sci. [Paris], 154 (1912), No. 6, pp. 369, 370.

[3] Ibid., No. 8, pp. 524-526.

[4] Deut. Landw. Presse, 39 (1912), No. 23, p. 275.

[5] North Carolina Sta., Rpt. 1902, p. 50.

The results indicate that the sulphur in the soil is present largely in organic form, since the acid soluble and water soluble sulphur are relatively so small. No trace of sulphid was found on boiling the soil with hydrochloric acid. Doubtless the presence of large amounts of iron in the soil results in the formation of insoluble basic compounds of sulphur and this may explain the noneffect of sulphur fertilizer on the composition of rice plants grown in the soil, for, as will be seen later, in silica sand cultures, the composition is much affected.

The soil was subjected to steam distillation and only 0.001 per cent SO_3 in the distillate was found oxidized with bromin.

The soil contains an abundance of phosphoric acid but no large amount of chlorin.

In the following table is shown the composition of the water entering the rice field and the water standing on the last plat.

Analyses of water used on rice fields.

Constituents.	Artesian water entering rice trial grounds.	Water from last plat in field.	Rain water collected at experiment station.
	Parts per million.	*Parts per million.*	*Parts per million.*
CaO	6.5	6.6	
MgO	8.7	10.1	
Cl	73.8	63.9	
SO_3	8.8	9.0	3.41
NH_3	None.	Trace.	

This irrigation water flows over the field and amounts to 25,700 gallons per acre per day and doubtless the plant obtains some of its chlorin and sulphur from the water standing about its roots.

Sulphur trioxid amounted to about 9 parts per 1,000,000 and chlorin to 70 parts per 1,000,000.

Analysis of rain water collected at the experiment station showed 3.41 parts per million of SO_3. But as the rice trial grounds are situated farther from the hills, they received almost no rainfall this year and the soil would receive no sulphur from this source.

The author took advantage of samples of rice grown in pot cultures for nitrogen work as outlined in Bulletin No. 24 of this station. The plants had received in addition to a basic fertilizer lacking nitrates, as given by MacDougal,[2] calcium sulphate and the several forms of nitrogen as shown in the table.

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[1] Analytical Chemistry.—Quantitative Analysis. New York and London, 1909, 1. ed., vol. 2, p. 282.

[2] Text-book of Plant Physiology, New York, 1901, p. 225.

Total sulphur as SO_3 in moisture-free material (pot cultures).

Fertilizer.	Straw.			Paddy.		
	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Check	0.215	...	...	...	...	...
$(NH_4)_2SO_4$	.239	0.667	0.449	0.328	0.405	0.444
$Mg(NO_3)_2$	.221	.380	.262	...	.318	...
$NaNO_3$	.388	...	.274	.263	...	...
$Ca(NO_3)_2$	.267	.343	...	.319	...	...
NH_4NO_3	...	.508	.310	...	.294	...
$(NH_4)_3PO_4$	...	.341	...	...	.302	...
Soy bean cake	...	...	...	.327	...	...

In this table no consistent influence can be seen on the sulphur composition of the plants grown in pots containing trial-ground soil. But in those plants grown in the silica-sand pots the total sulphur content is higher in every case and constantly higher when the soluble ammonium sulphate was the fertilizer added. In the following table the mineral sulphur in the plants is shown.

Mineral sulphur as SO_3 in the plants.

Fertilizer.	Straw.			Paddy.		
	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Check	0.052	...	...	...	...	...
$(NH_4)_2SO_4$	.106	0.435	0.148	None.	None.	...
$Mg(NO_3)_2$	.069	.163	.070	...	None.	...
$NaNO_3$	.698	...	.076	None.	...	...
$Ca(NO_3)_2$	.061	.152	...	None.	...	...
NH_4NO_3	...	.309	.098	...	None.	...
$(NH_4)_3PO_4$	...	.175	...	...	None.	...
Soy bean cake	...	...	...	None.	...	...

These results indicate the increase of total sulphur in the straw to be almost entirely due to mineral sulphur absorbed by the plant.

Phosphoric acid in moisture-free plants.

Fertilizer.	Straw.			Paddy.		
	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.	Trial grounds, submerged.	Silica sand, submerged.	Silica sand, not submerged.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Check	0.227	...	...	...	...	...
$(NH_4)_2SO_4$	.176	0.162	0.285	0.784	0.849	0.924
$Mg(NO_3)_2$	.247	.262	.296	...	.761	...
$NaNO_3$	.190	...	.253	.812	...	...
$Ca(NO_3)_2$	.207	.200	...	.671	...	...
NH_4NO_3	...	.158	.252	...	.750	...
$(NH_4)_3PO_4$	...	.201	...	...	.802	...
Soy bean cake	...	...	...	.836	...	...

The phosphoric acid content was found to be fairly constant throughout this series of plants.

In the table given below are the analyses of plants grown by the author in silica-sand pots with the view of verifying the previous results. The chlorin absorbed was about twice as high as that absorbed by the rice plant grown in normal soil conditions. These results with silica-sand cultures show the sulphur fertilizer is not rendered insoluble to the plant as is the case in soil cultures. They show the probability of the absorption of ammonium sulphate as such by the rice plant as so much mineral sulphate is found in the foliage, and free ammonia was determined in the water solution of two rice-plant samples.

Plants grown submerged in silica sand.

	Ammonium sulphate.	Calcium sulphate.	Check.
	Per cent.	*Per cent.*	*Per cent.*
Total SO_3	0.852	0.531	0.409
Mineral SO_3	.629	.312	.095
Cl	1.231	.969	1.266

The author made some determinations of phosphoric acid in the solutions obtained from sulphur determinations by fusion with sodium peroxid. The molybdic precipitate was dissolved and reprecipitated to exclude silica. The results as given in the following table compare favorably with those obtained by ignition with magnesium nitrate (official method):

Content of phosphoric acid as shown by different methods.

Number.	Na_2O_2 method.	Air-dried material, $MgNO_3$ method.	Number.	Na_2O_2 method.	Air-dried material, $MgNO_3$ method.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
8 (grain)	0.731	0.726	18 (straw)	0.272	....
9 (straw)	.163	.138	35 (grain)	.740	0.771
12 (straw)	.261	.223	36 (grain)	.702	.842
15 (grain)	.626	.593			

Also results obtained by boiling samples with HCl and HNO_3 compared with those obtained by boiling with H_2SO_4 and KNO_3 (official method)[1] are as follows:

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[1] U. S. Dept. Agr., Bur. Chem. Bul. 107 (rev.), p. 2.

Content of phosphoric acid as shown by different methods.

Number.	Straw.		Number.	Grain.	
	H_2SO_4-KNO_3 method.	HCl-HNO_3 method.		H_2SO_4-KNO_3 method.	HCl-HNO_3 method.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
24	0.255	0.189	34	0.831	0.249
25	.197	.201	35	.842	.225
26	.266	.182	36	.771	.223
27	.212	.198	37	.781	.216
28	.294	.202	38	.803	.255
29	.233	.164	39	.730	.212
30	.222	.154	40	.725	.221
31	.220	.188	41	.727	.230
32	.260	.268	42	.778	.245
33	.267	.199	43	.771	.223

It is evident that the results obtained from the straw analyzed by the two methods are not greatly different, but those obtained by boiling the grain with aqua regia until a colorless solution results are about one-third as high as those obtained by the sulphuric-acid and potassium-nitrate method. Although the solution of the grain obtained by boiling with HCl and HNO_3 becomes practically colorless, organic matter is still present, as shown by the charred mass that results if it is boiled to dryness. The starch may be oxidized to some organic acid that resists oxidation and interferes with the precipitation of the phosphomolybdic precipitate.

Thanks are due to Dr. W. P. Kelley, who suggested this work on sulphur in rice plants, and to Dr. E. V. Wilcox and Mr. William McGeorge, who gave helpful suggestions throughout the work.

REPORT OF THE AGRONOMIST.

By C. K. McClelland.

COTTON.

The work in agronomy for the year has been along the same lines as in previous years, although the work with cotton has been given the most attention. This work with cotton was deemed of first importance because the culture of the crop is not yet upon a paying basis, and it was thought that an effort should be made to get all information possible in regard to the crop so that it would be possible to suggest the proper methods of management. Many of those who planted cotton within the past few years have been compelled to abandon it, owing to improper conditions of environment or to the ravages of the pink bollworm, which continues to be the principle insect destroyer of cotton.

During the year the agronomist visited the fields of cotton upon Kauai, and the assistant in agronomy visited those upon the leeward side of Hawaii. Also from time to time as opportunity offered, trips were made to the various fields situated upon Oahu.

A press bulletin upon Cultural Methods for Controlling the Cotton Bollworm [1] was published in the fall of 1911, showing what success was obtained in fighting the bollworm by the use of lantern traps, by pruning, and by clean culture. Later, another press bulletin [2] was issued giving general directions for growing the crop and giving a discussion of various varieties and practices, with such recommendations as could be derived from the study of the crop on Oahu and upon the other islands.

Briefly, these suggestions were to attempt to grow the crop only on lower elevations or at least in fully protected places; to grow Caravonica in extremely dry locations and Sea Island, if preferred, in moister situations, but that so long as the bollworm is present to grow it as an annual.

It will be sufficient here to add that because of the unusual extreme drought during the winter and spring months the prospects for the 1912 crop are far from promising. Some of the planters waited until late in the spring for rains which never came to do their pruning, and finally were compelled to go ahead without the benefit of rains to start the new growth. Under such conditions high pruning is advisable, but in some cases low pruning was resorted to, and the buds which started were not able to continue their growth but remained at a comparative standstill until into the month of June. Under other conditions where the work was done in the fall or where rains were more abundant in the spring the prospects are brighter and a medium crop at present is assured. With the prevailing low price for cotton and with a seemingly limited demand, together with the great damages still being worked by the bollworm, it would seem that prospects for cotton in general are not especially bright.

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[1] Hawaii Sta. Press Bul. 32.

[2] Hawaii Sta. Press Bul. 34.

Some samples of saw-ginned and roller-ginned Caravonica cotton were submitted to a New England firm which makes a specialty of carded cotton for woolen mills. The samples were run through the picking and carding machines and the shrinkage or waste was determined. The saw-ginned cotton suffered a loss of 9⅛ per cent and the roller-ginned only 7¼ per cent, which is about the same, the firm says, as is lost from Peruvian cotton. They consider the roller-ginned cotton, since it has about the same roughness as the Peruvian cotton, to be equal to it and allowed 18½ cents a pound for it, which was the price of Peruvian upon the market there at that time. For the saw-ginned cotton they allowed 18⅛ cents, or three-eighths cent less per pound.

At this price for cotton, not considering the cost of the roller gin, which costs double the amount that the saw gin costs, the excess of cost of ginning upon the roller gin greatly exceeds the extra amount which was received for the cotton; and if the price were greater the difference would be still greater in favor of the saw ginning. If the work is carefully done, then the profit is greater by using the saw gin, but if carelessly done and if the gin is run at too great a speed the damage may be greater than here reported, and the difference in price would be more.

This opinion, coming from a firm of recognized authority and who use cotton in large amounts annually, may be taken as settling the question of the use of the saw gin, which has been debated among the cotton growers of Hawaii. To one buying a gin, the difference is in favor of the saw gin, but to one already operating a roller gin the difference is not such as would justify an exchange of gins.

RICE.

The rice experiments have been continued as heretofore, and, although the rice-trial grounds will have to be given up at the end of this year, another small field will be obtained and the work continued. The introduction of the Japanese varieties among the Chinese growers progresses very slowly. The growers are loath to plant a rice for which they have in the past had to accept a lower price than they obtained for their other varieties. However, seed of two varieties was given to three growers in considerable quantities, and as these two varieties have been grown in Hawaii for several generations, an effort will now be made to give them a thorough culinary test and determine if possible what has been the effect upon them of the soil or climate.

In this connection it is interesting to note that in the Kapaa District of Kauai, a Japanese was found who claims to have been growing the Shinriki variety for the past nine years and that he finds it as good to-day as it was in the beginning. In the vicinity of Pearl Harbor, where this variety is grown on a large scale from seed obtained from the station, it is said that the Japanese are eager to obtain it and that the crop is rushed as soon as harvested to the mill and prepared at once for their use. From these two encouraging reports it would seem possible in time to grow a rice that will completely fill the requirements of the Japanese consumers.

SEED DISTRIBUTION.

During the year there has been quite a demand for seed of various kinds and it has not always been possible from our limited stock to fill all demands. Seeds of soy beans, pigeon peas, peanuts, broom corn, alfalfa, velvet and jack beans, various sorghums, and also roots of several prominent grasses have been sent out in answer to demands. Especially among the homesteaders has there been a great demand for these seeds.

DRY FARMING.

Some cooperative experiments were attempted upon a dry-land basis in a district out from Honolulu which is noted for its dryness, but no results have been obtained, for the reason that while heretofore in this region there has always been some rain during the year, for this once at least the rains failed entirely, and all the various crops tried have completely succumbed to the drought. The wind across this region is strong during most of the time and this, together with the lack of a percolating rain, caused the failures.

A small grass garden was started in the fall upon a very dry field located upon Magazine Street and a number of grasses and legumes were planted. Rescue grass and crimson clover were very promising at first but in the end probably the best showing was made by the Australian water grass. At present only this grass and some alfalfa seem to be alive, the others being dried up and withered by the extreme wind and drought prevalent there. Berseem and bur clover matured seeds, also rescue grass, but the majority of the grasses did not.

BROOM CORN.

The experimental work with broom corn has been continued upon a small scale. That planted in April, 1911, yielded at a rate of 311 to 658 pounds of brush per acre, the lower yield being obtained from the outer edge of the field near some algaroba trees which are far reaching in their influence. This brush was of excellent quality and was from 24 to 30 inches in length, which is longer than is desired by the broom manufacturers. Closer planting under the same conditions would have restricted the length. The crop occupied the land but 90 days and was sold for 6½ cents per pound.

The crop was allowed to ratoon and proved a failure, the yield being much less than at first, while the quality was very inferior, each stalk having coarse central stems in the brush. Perhaps better conditions of moisture would have produced a better result, but a ratoon crop under our dry summer conditions is inadvisable.

Another small area was planted December 20, 1911, from seed obtained in San Francisco. A period of dry weather followed with late winter rains. The brush obtained from this planting was of about the same quality as that obtained in the previous ratoon crop. This poor quality might be due either to the use of run-out seed, to the effect of the dry weather in the early stages of growth, or to the effect of the cool weather at the time of heading out. Some of this same seed was again planted April 4, 1912, and began heading out about the middle of June, the heads at this season being almost entirely free of the objectionable center stems. It would seem from this one experience that fall planting is undesirable; but another planting will be made to try and find out the exact cause of such poor quality.

From experiments thus far made it appears that there is a small profit only to be obtained in growing broom corn. As corn produces well in the winter months, it would be well to grow corn at this time and then to plant the broom corn after the corn in April or May. Where only small areas are grown and no machinery is used a good plan is to plant the broom corn in the rows between the corn, and especially if the corn is to come off late in the spring. In midsummer, provided there is sufficient moisture to start the seed, soy beans or other legume may in turn be planted between the rows of broom corn for green manure or other purposes. In this manner a return of about $30 per acre may be obtained for the use of the land for only about 90 days.

GRASSES AND FORAGE PLANTS.

The problem of grasses and legumes for hay, soiling crops, and pasture is very important, although for several years some attention to this subject has been given by the managers of the various ranches upon the different islands. The requirements are varied, and the conditions of environment are so greatly changed within short distances that it makes the problem even more difficult. The greatest demand of course is for suitable grasses for pasture, and for different ones that will be useful at different times. For winter months or for summer months; for wet districts or for dry; for districts with both a wet and a dry season; for low or for high elevations; for reasonably good and for poor rocky barren soils—these are the variations of environment for which it is difficult to obtain suitable crops.

From time to time upon the ranches a number of grasses have been introduced and tried out with the hope of finding a few which would answer requirements and thrive under the given conditions of environment. Although doubtless as many as 50 different species have been tried but few of them have been found that were especially valuable.

Another want is felt by the dairymen for a legume crop to grow in rotation with sorghum in the winter months for soiling. Alfalfa when once seeded is too valuable a crop for short rotations; soy beans have not produced desired amounts; the same was true for cowpeas, which were badly attacked by aphids; velvet beans and jack beans grew too slowly to give any satisfaction; and each crop tried seemed to be lacking in some important point.

For hay there is a considerable demand only in the larger towns and also by the Government for the Army horses and mules. Considerable quantities of Ajax wheat hay are brought in from California. Upon the plantations cane tops furnished the greater part of the roughage in the rations. Some alfalfa is imported and there is a small amount grown and cured here. Pará grass and Guinea grass are used to some extent, but these, like alfalfa, are more often used as soiling grasses and fed when freshly cut. Rhodes grass and Natal redtop have been recommended for hay crops under various conditions, the former being especially drought resistant.

In order to glean what lessons have been learned by these various experimenters and to be able to give their experience to others interested, it is the intention to make a careful study of these trials upon the different ranches from time to time as opportunity offers, and already some important lessons have been derived from a study of the methods used in improving pastures and conditions in general upon the Princeville plantation near Hanalei, Kauai.

RANGE IMPROVEMENT.

The ranch known as Princeville plantation consists of about 12,000 acres in the Hanalei district of Kauai varying in elevation from sea level to 1,000 feet above. On the lower lands are now some 700 acres in rice while the upper lands, several thousand acres in extent, are precipitous and covered with forest. The pasture lands lie mostly between 300 and 800 feet in elevation and are cut up here and there by several deep gulches. In places these gulches are very wide and formerly were swampy and many animals were lost in them. There was also a considerable loss in the high lands from cattle falling over the bluffs or from the narrow trails along the gulches.

The pasture lands were covered with a heavy growth of lantana and of guava, averaging from 15 to 18 feet in height. To subdue these shrubs, buffalo grass (*Stenotaphrum secundatum*) was introduced in 1902, 100 acres being planted, and from then until 1908 about 900 acres more were planted with this grass.

In 1905, Mr. W. F. Sanborn, the present manager, was placed in charge and a more scientific and practical effort made to achieve good results. From the practical point of view it was reasoned (1) that land covered with guava and lantana, neither of which were of value as forage, could carry only a small fraction of as many cattle as it could if these shrubs were destroyed; (2) that if the innutritious and unpalatable grasses, such as Hilo grass and other native grasses, were supplanted by better ones, this would also help to increase the carrying capacity of the pastures; (3) that if the quality of the cattle were improved by using pure-bred sires from some credited beef breed, within a few years it would be possible to produce a pound of beef upon much less feed than was required to produce that amount in scrub cattle; and (4) that by draining the swamps and by fencing off the cattle from the bluffs and precipices, losses from such sources would be eliminated.

Experiments were undertaken in a scientific manner to determine what grasses would thrive under the given conditions, what were the best methods and times of seeding, and finally out of those grasses which thrived to select those which would stand grazing and would not be crowded out by native or less valuable grasses when grazed by the cattle. To determine this more than 30 different grasses and legumes were planted in small plats in three different locations under slightly different conditions. The results to date are not conclusive, but indicate roughly what is to be expected from many of these under the given conditions.

Since 1905, about 3,000 acres have been cleared of guava and lantana. After grubbing these out the land was plowed shallowly with sod plows. After such time as was necessary for the rotting of the roots the land was harrowed, then cross plowed more deeply than at first, and later still another harrowing, plowing, and another harrowing were given. Although moisture conditions were often favorable for spring planting yet it was learned that because of attacks of cutworms, it was always expedient to plant in the autumn; also that to cover the seed with a smoothing harrow very often resulted in failure, as the young plants were likely to die out if dry weather followed soon after the seed germinated. A better plan was to harrow with a heavy spike-tooth harrow, leaving the surface in small ridges, over which the seed was then broadcasted, allowing the rains to cover the seed. By this method it was observed that even if the plants upon the ridges died out, those in the little furrows between, having the benefit of more moisture and greater protection from wind, usually survived and insured a stand.

The rainfall varies greatly in this district. It may be as low as 30 inches at some points along the coast and it may be as high as 200 inches in some years at the highest points of the hills, probably 60 inches is a fair average for the greater part of the land where the seeding has been done. It will be seen from this that conditions for growth of grasses are much better than could be found on the leeward side of any of the islands.

In addition to the 1,000 acres of buffalo grass above mentioned there were planted in the beginning about 4 acres of Para grass, 20 acres of Guinea grass, and a small area in alfalfa from which fields hay is now obtained for the mules and horses.

There were planted in 1909, 40 acres of *Paspalum dilatatum* and also 350 acres of *Agrostis vulgaris*, or redtop, and *Dactylis glomerata*, or orchard grass; in 1910, 500 acres of *P. dilatatum;* in 1911, 400 acres of *P. dilatatum* and of orchard grass mixed, using, per acre, 10 pounds of orchard grass to 5 of the Paspalum; also in 1911 about 30 acres were seeded to *P. virgatum* and *P. compressum*. This year, 1912, 400 acres will be planted to *P. dilatatum* and *P. virgatum* and Natal redtop, using 10, 3, and 2 pounds per acre, respectively.

This makes a total of about 2,700 acres which will have been seeded to tame grasses for pasture. Hereafter about 200 acres will be seeded annually until all arable land is planted, after which some of the buffalo grass will probably be replaced.

The fields are now divided into 10 paddocks and the cattle into 6 herds, which allows a period of recovery in each paddock by occasionally changing the herds to fresh pastures. The swamps have been drained and the cattle fenced from the rougher mountain lands, and in addition to the saving of losses from these sources it has been noticed that the cattle suffer less from the liver fluke than before the drainage was done. The loss of calves in 1912 was only 0.3 per cent, all of which occurred in animals under 6 weeks of age. The herd has been increased from 900 head in 1905 to 2,000, and it is evident from the looks of the pastures that a further increase of at least 75 per cent would not damage them. There are now 19 pure-bred Hereford bulls and 10 heifers of different ages, some of which were imported from Missouri, Iowa, California, Washington, and from New Zealand. This number is sufficient to furnish a home supply for breeding purposes for several years. The original stock, which dresses 400 to 500 pounds at 5 or 6 years of age, is gradually being replaced by half-breed Herefords, and it is hoped that within a few years they will be able to sell animals dressing twice as much at one-half the age.

NOTES UPON VARIOUS GRASSES.

(1) It was noticed upon the newly seeded lands that the ground was first covered with kukaipua (*Syntherisma sanguinalis*), white honohono, and so-called glue bush. These annuals, the first two of which make good grazing, shade the land and protect the tame grasses from the sun and wind, thus giving them a better chance to grow. When the latter have attained some size, nothing more is seen of the former.

(2) In planting orchard grass with paspalum the former seems to grow more rapidly at first and furnish grazing much sooner than the latter, and it is more valued because of this habit.

(3) Natal redtop seems to be better for hay than for grazing, but has some value for pasture when mixed with other grasses.

(4) *Paspalum dilatatum*, *P. virgatum*, and *P. compressum* each seem to have the power to crowd out Hilo grass (*P. conjugatum*). All of them are very promising as pasture grasses and are spreading over the adjoining fields. Which of them will be the most persistent is yet to be determined.

(5) It was observed when trying to start *P. dilatatum* from roots placed in the open fields that the cattle ate it greedily, pulling it up or pawing it out before it had time to get well rooted. However, when a plat containing several finer grasses was thrown open for pasture they grazed the latter as closely as a lawn is clipped. but allowed the coarser paspalums to attain greater size.

(6) Orchard grass, creeping bent, Rhode Island bent, Kentucky blue grass, Italian rye grass, Natal redtop, *Paspalum floridum*, and other grasses which seemed to start well are very likely to be crowded out by the coarser paspalums because of this close grazing by the cattle and because of the greater vigor of the latter.

(7) Rescue grass, velvet grass, and a mesquite grass were crowded out by other grasses. Rescue did especially well in the plats at first.

(8) White clover was completely eaten up or rooted out by the cattle.

In view of the fact that in the United States all of the old cattle ranches are being transformed into smaller farms and given over to the production of field crops as well as the raising of cattle, and that the feeding of the cattle upon these farms will in the future be a more important work than the grazing of them, it is perhaps to be wondered why at this time an owner would think of seeding down a ranch to grass and planning to raise cattle by grazing only. It is true that in Hawaii some of the ranches have followed the lead of those in the United States and have given up the cattle business and devoted the land to the culture of crops, either cane or pineapples, and that is proper since with these crops there is an assurance of greater returns per acre than with cattle; but at Hanalei there is such a heavy rainfall that a good growth of grass is at all times insured, so that with good stands of palatable tame grasses the carrying capacity of an acre is much larger than would obtain upon lands on the leeward sides of the islands or in the regions in the United States which were in the past devoted to the cattle ranches. Furthermore, a market for the beef is assured right at home upon the island of Kauai, and as such supply is necessary it is fitting that the supply of the need should be undertaken in a scientific and businesslike manner, which, it would seem from this study of methods, has been done.

Upon rougher and rocky lands such a practice would be out of the question and methods used under these conditions would be more laborious, expensive, and in the end would result in stands less perfect than is possible by the method described; and the carrying capacity of an acre could never equal that in the case given. However, the best method in which to work over rocky and rough lands is worthy of study and may be reported upon later.

REPORT OF THE SUPERINTENDENT OF THE HAWAII SUBSTATIONS.

By F. A. Clowes.

HILO SUBSTATION.

The Hilo substation comprises approximately 1¾ acres of land bordering on the farm of the Hilo Boarding School. The use of this land was granted to the experiment station by the Territorial government in December of 1910. The experiment station entered into a cooperative agreement with the Hilo Boarding School, whereby the school supplied all the unskilled labor, mules, and farm machinery for the plats and the experiment station directed the work. This arrangement has been very satisfactory and valuable work has been accomplished.

Three lines of work have been carried on, namely, experimental work with upland taro, experiments with bananas, and demonstrations of leguminous crops for feeding and green manuring.

Two taro experiments were planted and harvested during the period under report. The first was one to determine the relative value for seed of the three classes of seed or hule, namely the makua or parent hule, the oha or hule from the large lateral corms, and the puu or the small lateral hules planted entire. The other taro experiment was a fertilizer test. These two experiments covered an area of three-fourths of an acre. (The results will be published later in bulletin form.)

A plat 120 by 135 feet is devoted to a test of planting Bluefields and Hamakua bananas at distances apart of 8 by 8 feet, 10 by 10 feet, 12 by 12 feet, and 15 by 15 feet. At the time of planting there was uncertainty as to identification of the Bluefields and the Hamakua bananas. These two varieties are so similar that it was impossible to get a clear and distinctive description of each. It was the intention to plant the experiment with the Bluefields, but it was impossible to secure a sufficient number of plants that were genuine Bluefields. Sufficient Bluefields were secured, however, to plant one row across each plat of the experiment, and a sufficient number of the Hamakuas to plant another row across each plat of the experiment were secured. All the other plants used were of a mixed lot which at the time could not be separated into Hamakua and Bluefields.

At the time of planting it was noticed that the Hamakua suckers were of a deep purplish red color at the base, while the Bluefields were of a lighter pink color. This was found to be a constant difference between the suckers of the two varieties. The Hamakua always tends to have a dark red color on the stalk below the ground, while the Bluefields is of a light pink color. Another readily noticeable difference is that the midrib of the Hamakua leaf is green, with little if any tendency to pink color, while the Bluefields has a decided pink or red color to the midrib. This difference is particularly noticeable in the suckers of the two varieties. Moreover, the Bluefields are about 1 foot taller.

The bananas in this experiment, having been planted in June, 1911, are not yet matured. The results are, therefore, not yet available.

Small plats of soy beans, cowpeas, pigeon peas, jack beans, velvet beans, and alfalfa are grown in order to demonstrate to stock raisers of the surrounding region the crops which could be profitably grown to supplant grain in cattle rations.

GLENWOOD SUBSTATION.

The Glenwood Experiment Farm (Olaa substation), consists of 16½ acres of land situated on the Volcano Road at Glenwood. The elevation above the sea is 2,300 feet. The land has a good slope to the southeast. The soil is deep and with the exception of a small area has good natural drainage. The buildings, which were erected previous to July 1, 1911, are a superintendent's cottage, and a farm building containing office, storeroom, workroom, men's dormitory, horse stable, implement shed, and tool rooms. There have since been added to this equipment a cow stable to accommodate four cows, and a building 14 by 18 feet for dairy purposes. The equipment for this is now ordered, and consists of a 3-horsepower steam boiler, a 1-horsepower steam engine, turbine Babcock tester, combined churn and butter worker, and the necessary utensils and accessories for the production of first-grade farm creamery butter. A power separator has been donated by Mr. B. F. Dillingham.

Tributary to this experiment farm is a large area of apparently good land, much of which is public property available for homesteading purposes. A considerable area of privately owned land has been cleared of the heavy growth of ohia forest that originally covered it. At one time there were extensive coffee plantations laid out here, but after the first crop further profitable crops were not obtained. Following the coffee, much of the land was planted to sugar cane. The results with this crop have almost uniformly been that only first cuttings were profitable, the ratoons almost always proving financial failures. Tobacco was at one time successfully grown, but the settlers who raised it were unable to secure a market, and had to give up their homesteads and seek a living elsewhere. At present much of the cleared land is under lease to ranchers and is affording pasture for range animals. A promising butter business has survived the agricultural misfortune of this region and one grower is raising easter lilies and pohas (*Physalis peruviana*) with fair success.

There are evidences of extensive agricultural work in this region in the days of abounding native population. The native bananas (mauli type) are found growing in extensive plantations, olena (*Curcuma longa*), mamake (*Pepturus albidus*), loulu (*Pritchardia gaudichaudii*), taro, and sweet potatoes are among the plants found growing in what would otherwise seem to be primeval forest, but in reality bears clear evidence of extensive prehistoric agriculture.

The rainfall in this region is in the neighborhood of 200 inches a year. The elevation is such that there are comparatively few days without a fall of rain. This makes field work disagreeable and renders the soil sticky. Unless great care is exercised, attempts to carry on horse cultivation serve only to puddle the soil and to produce a hardpan that is impervious to water. The tramping of the cattle in the pastures renders the surface so impervious to water that except in dry weather the surface soil is always in a condition of saturation. The soil temperatures are low, and on account of the elevation the air is cool. Plant growth is very slow. Cutworms and slugs are abundant, and the prevention of their ravages constitutes one of the big problems of the region. The moist conditions favor the presence of plant diseases. The saturation of the soil with water precludes oxidation, and the seepage of soluble plant food renders the soil lacking in plant food in quantities that would produce the most profitable crops without frequent application of fertilizers. The lack of air and the unoxidized and poisonous nature of the subsoil retards the downward progress of roots. Hence what would, from its friability and freedom from stones, seem to be a very deep soil is in reality a very shallow one.

This brief description will serve to illustrate the practical problems for the solution of which the Glenwood Experiment Farm was established.

The dairy business in this region depends at present upon extensive cheap pasture and an abundance of wild honohono (*Commelina nudiflora*) for soiling purposes. It does not rest upon a permanent foundation. Cattle thrive in this region, and the country seems to be adaptable to the live-stock industry. It has seemed wise, therefore, to devote considerable effort toward establishing the permanence of the dairy and live-stock industries. Much space and time are given to experiments on fodder crops. It is also intended to operate a small farm creamery for experimental and educational purposes, in the hope of establishing the market end of the business upon a firm basis.

Besides the dairy work in its two branches, experiments are in progress with a great variety of market crops. A study is also being made of methods of cultivation, soil treatment, and drainage. Fertilizers are also being tried out with the aim of determining the requirements of the various crops upon these soils. A demonstration and experimental wood lot is also being planted.

Much of the time during the past year has been devoted to the rough work of removing stumps and otherwise preparing the land for systematic experimenting. Small plantings have been made of various crops at all months of the year with the idea of studying the effect of unseasonable plantings and also to find crops which gave sufficient promise to justify larger plantings. In the further development of these trials there have been planted the following forage crops:

Para grass, one-half acre; Japanese cane, one-half acre; honohono or commelina, one-half acre; corn and sorghums, 1½ acres; (of these 40 varieties are under trial); dwarf Essex rape, one-fourth acre. In addition the following have been planted: Broom corn, one-fourth acre; sugar cane for milling, one-half acre (four varieties); and pohas or ground cherries, one-fourth acre. These last grow wild in this region and the fruit sells readily as a canning crop. It is desired to determine if they can be cultivated profitably. There is also about a quarter of an acre devoted to variety and fertilizer tests on vegetables and flowers. Of these the following have given results which are believed to warrant the planting of larger areas: Cabbages, cauliflower, strawberries, Easter lilies, cucumbers, pole beans, rutabagas, and kohl-rabi.

Preparations have been made to plant about a quarter of an acre of cooking bananas.

Other crops which have given promise as forage are field peas and oats. It is intended to plant these on a larger scale. Small trials are being made of grasses (20 varieties), clovers (11 kinds), vetches, oats, flax, buckwheat, spelt, emmer, wheat, millet, peppermint, ginger, *Canna edulis*, awa, asparagus, potatoes, sweet potatoes, and bananas (8 varieties).

In the woodlot plantings of all the trees commonly grown for such purposes throughout the Territory have been made. Others will be tried later.

Other trees and shrubs planted are apples, walnuts, camphor, Chinese oil-nut tree, rose apple, and mammee apple.

The fertilizer work is incomplete. Enough, however, has been accomplished to show that even on new land fertilizer gives decided beneficial results. Stable manure has given better results than applications of complete high-grade commercial fertilizer. On abandoned cane land that had been used for pasture for several years 500 pounds of complete high-grade fertilizer was needed to produce even a fair crop of corn. It is evident that heavy fertilization is needed, and apparently this should be applied as often as once every three months.

Acknowledgment is made of the many kindnesses of the business men of Hilo, the officials of the Olaa Sugar Co., and many others who have shown interest and given much help in the work of equipping and establishing this substation.

REPORT OF THE SUPERINTENDENT OF THE RUBBER SUBSTATION.

By W. A. Anderson.

TAPPING CEARA RUBBER.

The Ceara tapping on the Nahiku plantations has been directed chiefly toward the development of a system of tapping that would yield the largest amount of rubber per unit of labor without injury to the tree, and curing the product in such a way as to make it satisfactory to the manufacturers.

Many methods which would give profitable results in most tropical countries with their cheap labor, were found to be impracticable here with labor at approximately $1 per day. No satisfactory incision method for tapping the Ceara tree without removing the outer bark has so far been found. At the same time, aside from the expense involved, the injury which results from the frequent stripping of the entire outer bark makes this undesirable.

In July, 1911, after a considerable amount of experimenting, tapping on a commercial scale was started by removing the bark to a height of about 18 inches and pricking with a wheel pricker making pointlike incisions, run vertically, on four sides of the tree at each tapping. The latex was allowed to run to the ground and left there until the following day when it was coagulated. The rubber was then collected, in a very dirty state, washed with a single macerator, vacuum dried, hung in the air for one to two weeks, and then shipped. The average yield per day's labor involved in preparing the trees, removing the bark, tapping, and collecting, on 5-year-old trees, on 70 acres, in two months, was approximately 2 pounds of washed rubber. It was found that after two weeks of tapping daily, the yield fell off to such an extent as to indicate the suspension of tapping.

On trying to resume operations after a rest of two weeks, it was found that the flow of latex was hindered by the new outer bark, that was forming a scaly, powdery covering which gradually became thicker and tougher, preventing the flow so that this form of incision could no longer be profitably made without stripping the bark again. Experiments in removing the bark on the 18 inches next higher up showed that too little latex reached the ground and that which remained on the tree could not be readily collected. Jabbing with a flat knife blade, making a horizontal incision on this newly stripped area, gave a better flow of latex, but the expense of collecting proved this impracticable, both with and without a previous application of acetic acid.

These experiments, however, demonstrated two fundamental facts: First, that a knife jab made horizontally gives better results than one made vertically; second, that the portion of the tree just above the ground, to a height of about 6 inches, yields rubber in much larger quantities than any other portion. This area is never tapped when collecting cups are used, as the spout is necessarily inserted high enough to conduct the latex to the cup, set on the ground, and the tapped area is all above the spout, and, consequently, above the most prolific section of the tree.

The second of these facts was utilized in the development of a system which has undoubtedly given better results in proportion to the labor involved than any other. By this method, the bark is removed to a height of about 6 inches and cuts made with a very thin knife blade from the ground to the top of this stripped surface. The latex is allowed to flow to the ground and coagulate. The following day the rubber is collected and new cuts made at the same time.

The advantages are obvious. Only the richest portion of the tree is utilized, and at the same time, the portion where injuries heal most quickly After the first cutting, the collecting and cutting are performed at the same time, thus saving one-half of the walking that would be necessary in passing from one tree to another if there were separate operations. The cutting knife is used to facilitate the removal of the rubber from the soil in collecting, so that there is no time lost in changing tools. The laborer carries his bucket in one hand and his knife in the other, sets the bucket down, naturally nearest the hand that is freed, slips the knife under the lump of coagulated rubber, on the ground, lifts the rubber with the free hand, aided by the knife, deposits it in the bucket, and makes his new cut in the tree with the knife in the other hand, lifts the bucket with the free hand and passes on. It would seem that the number of motions involved is reduced to a minimum. The largest amount of rubber collected in this way, by one man in one day of 10 hours' tapping and collecting, is 9 pounds of washed rubber, though the average yield for 100 acres during six months' tapping is somewhat less than 4 pounds.

The disadvantages lie chiefly in the fact that so small a portion of the tree is tapped. The yield per tree at each tapping is small, in some cases 1 pound of washed rubber to 400 trees. The number of tappings possible per year, as indicated by a six months' trial, is about 48, with two strippings per year. The removal of bark appears to be less injurious on this area than higher up, and it is probable that the trees would stand this removal. Each stripping after the first is more difficult, as the cuts make the renewed bark very rough and it breaks off in small patches instead of coming off as one sheet, as is the case with the first stripping. If the cut is made properly it heals without a ridge and more quickly here than elsewhere on the tree. Attempts to continue this method higher up on the tree have not so far proven successful.

Having thus found approximately the maximum yield per day's work, attention was directed toward increasing the yield per tree, with a view to getting a proper adjustment between these two, which will be the point of diminishing returns. As satisfactory results were not obtained by continuing to remove the bark in horizontal strips, vertical strips were tried. First, a strip about one-third inch wide was removed with a broad, U-shaped knife, gauged to remove only the outer bark, exposing the inner bark for incision. The incisions were made with a blade of the same width as the stripped surface, at regular intervals, along the length of the strip. In this way the yield per tree per tapping was increased, but too large a portion of the rubber remained on the tree as scrap, which could not be profitably collected. The application of a solution of acetic acid caused practically all the latex to coagulate on the tree, where it was collected to better advantage. To widen the stripped surface, a second cut was made 1 inch or more from the first, and the bark between these two cuts was removed. This is done quickly and simply. The wider strip is treated with acetic acid and incisions made at intervals of about 2 inches, with a blade 1 inch wide, so sharpened as to touch the cambium at only two points instead of along the entire edge. The rubber is collected one hour after tapping.

The experiment is not yet completed, only one week's tapping having been done. It is found, however, that one man can make the incisions as fast as two men can collect, and the three men in one day can incise and collect from about 800 trees exclusive of stripping, securing about 1 pound of washed rubber to 70 trees. Four tappings can be made on each strip before exposing a new surface. Including stripping and all labor, results for the week were at the rate of 2⅔ pounds per day's work.

For the purpose of comparing this method with the one previously described, which gave the maximum yield per day's work, we may call the former method A and this one B. Calling the average yield per day's work in A 4 pounds, and the average yield per tree one three-hundredths pound, we get 4 pounds from 1,200 trees in one day's work. In B we get 2⅔ pounds from 186 trees in one day's work. It is obvious that were the number of trees available unlimited, A would be the better method. Since on any plantation, however, the number of trees is necessarily limited, the total profit on labor from a given number of trees will determine the relative value of the two methods. From 50,000 trees A would give 167 pounds in 41⅔ days' work. At $1 per day and $1 per pound (the approximate present values), profit on labor would be $125.33. B would give 683.4 pounds for 268.8 days' work, leaving a profit on labor of $414.60 from the same number of trees, from which it appears that B is the more profitable plantation method so long at least as the value per pound of rubber remains greater than one-half the cost of a day's work.

This tapping was done in the last week of June. It is probable that better results can be obtained during the latter half of the year, as the trees are not in full leaf before the middle of July.

CURING AND MARKETING CEARA RUBBER.

The rubber obtained was shipped direct to manufacturers in New York. The first shipment, vacuum dried, was valued at 10 per cent below the best Para and sold on that basis. Two later shipments, treated like the first in every way, but not vacuum dried, were valued over 25 per cent below Plantation Pale Crepe. While the last shipment from which returns have been made, partly vacuum dried, was sold at 10 per cent below Ceylon Fine Pale Crepe, and brought $1.15 per pound. The rubber is now all being vacuum dried and pressed while still warm from the dryer into sheets about 2 inches thick, 10 inches wide, and 3 feet long, weighing approximately 20 pounds each. The loss in washing and drying rubber thus prepared has been found to be 2⅕ per cent.

The conclusions from the work so far done are that tapping method A is the cheapest and most desirable where the trees to be tapped would furnish work for all the labor available, but method B gives greater profit from a given number of trees, and that either method can be carried on commercially at a profit under present conditions. The product, though very unattractive as it comes from the field, is capable of being turned into rubber of the first class without too great expense.

Contemplated experiments on a commercial scale to determine the effect of fertilizers on the yield of latex have not been carried out, but it is hoped that some work of this sort can be done in 1912.

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